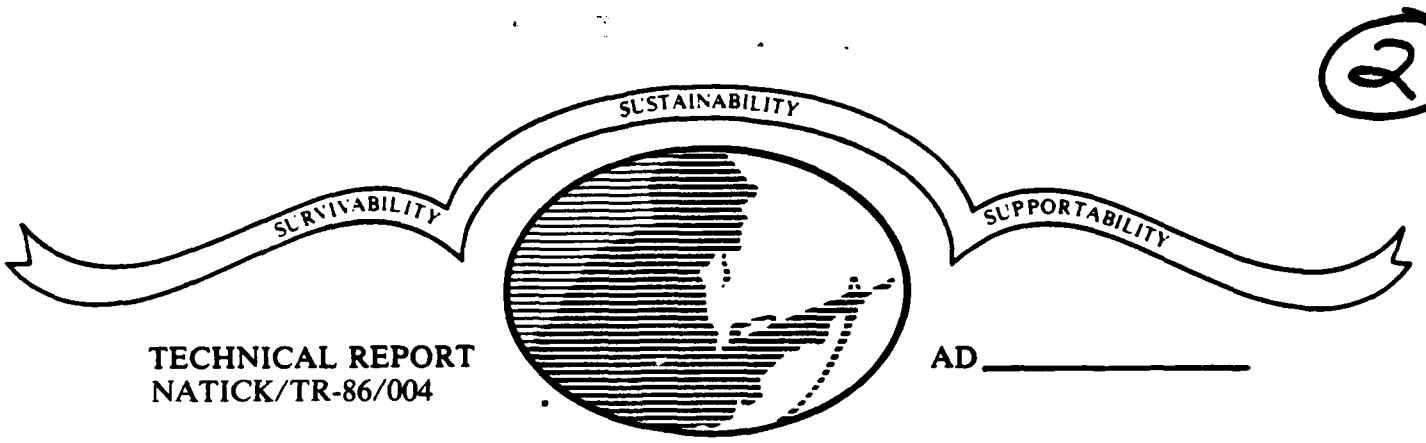

TECHNICAL REPORT
NATICK/TR-86/004

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DEMOGRAPHIC AND ANTHROPOMETRIC ASSESSMENT OF US ARMY ANTHROPOMETRIC DATA BASE

BY

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It has been nearly 20 years since the last anthropometric survey of Army males was conducted and about eight years since the last survey of Army females. The purpose of this report is to assess the extent to which the Army's existing anthropometric data base is representative of the current Army active duty force, both demographically and anthropometrically. The demographic variables of age, sex, and race are compared for the Army's existing anthropometric data base, the current active duty force, and the projected force of the 1990s. The

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changes in these variables occurring in the Army population are also contrasted with those occurring in the U.S. population at large. The anthropometric variables of stature and weight are compared for the existing data base and current active duty officers. Other anthropometric variables that are affected by race and age are also examined. Differences in anthropometric variables between the existing data base and the current active duty force are discussed in the context of secular trends in anthropometric measures from the U.S. population at large and other military populations. The implications of using the Army's existing anthropometric data base in the design and sizing of clothing and personal equipment are examined in light of the present and projected demographic composition of the Army active duty force.

PREFACE

This report was prepared to fulfill requirements of contract DAAK-60-84-C-0086 with the Individual Protection Laboratory (IPL) at U.S. Army Natick Research and Development Center (NRDC). The contract monitor was Dr. Claire C. Gordon of the Human Factors Group.

The authors are grateful to Commander William Moroney, U.S. Navy, Naval Air Development Center, Warminster, Pennsylvania, and to Ms. Beatrice Overton, Research Sociologist, Fort Benjamin Harrison, Indiana, for graciously providing information at their disposal.

The authors appreciate, finally, the thoughtful and thorough reviews of earlier drafts of this report by Dr. Claire Gordon, Dr. Carolyn Bensel, Mr. Charles Williams and Mr. Michael Statkus, of NRDC.

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INTRODUCTION

An anthropometric survey that is well planned and carefully conducted will provide data for analysis and design that can be used successfully over many years. Even the best survey, however, should be periodically evaluated to determine whether it is still representative of the total population. It is nearly 20 years since the last anthropometric survey of Army males, and about eight years since the survey of Army females.[1,2] In view of changes which have occurred in the U.S. Army, particularly with the advent of the all-volunteer induction system, it is appropriate to review the Army's existing anthropometric data base to determine the extent to which it is representative of the current Army active duty force. In the context of this evaluation, some projections will also be made about the applicability of the current anthropometric data base to design problems in the 1990s.

There are two interrelated ways in which an anthropometric data base may be representative of the larger population: demographically and anthropometrically. The demographic variables that will be considered in this report are age, sex, and race, all of which have an effect on the anthropometric variables.[3,4,5*] The direct comparisons of anthropometric variables for the current active duty force are limited to stature and weight, as these are the only variables for which current data exist. Nevertheless, the demographic variables listed above have an important effect on the statistical characteristics of many other anthropometric variables.[6] The representativeness of these other anthropometric variables can be assessed by inference from the analysis of demographic differences or similarities, as will be shown later.

The organization of this report is as follows. Demographic variables will be considered first. Age is compared for the existing anthropometric data base and the current active duty force. Sex is compared for the current active duty force and the projected force of the 1990s. It is not possible to compare the existing anthropometric data base to the current force with regard to sex ratio because military surveys have been exclusively sex-specific. The small number of men included in the 1977 survey of Army women was for comparative purposes and was not intended to represent all males in the Army.[7] Race is compared for the existing anthropometric data base, the current active duty force and for the projected force of the 1990s.

Long-term trends are examined with census data from the U.S. population from 1900 to 1980. The changes occurring in the Army are contrasted with those occurring in the population at large. These comparisons are made on race, age, and sex. Brief discussion is also devoted to comparisons of the Army data base with that of the other branches of military service.

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* There is considerable literature on this topic in anthropology and human biology. The references listed here are examples only.

Anthropometric variables, specifically stature and weight, will be considered in the third major section of the report. The anthropometric data base values are compared to data from the medical records of current active duty force officers, the only group for which such data are available. Other variables that are affected by race and age are also examined. The differences in anthropometric variables between the existing data base and the current active duty force are discussed in the context of secular trends in anthropometric measures from the U.S. population at large and other military populations. The design implications of these changes are discussed.

The last major section of the report deals with perceived changes in demographic patterns in combination with perceived changes in anthropometric dimensions. The implications of this combination of effects are far-reaching for design applications, both for clothing and for personal protective equipment.

SHORT-TERM DEMOGRAPHIC COMPARISONS

Age

The age distributions of the existing anthropometric data base and the current active duty force* are compared in Tables 1 through 4. Male officers and enlisted men are presented in Tables 1 and 2; females are presented in Tables 3 and 4. The customary way to compare discontinuous distributions over two groups is with the Chi-square (X^2) test.[9] This tests the null hypothesis that the two variables (age and sample) are distributed independently. Chi-square values and significance levels are presented for Tables 2 through 4. The Chi-square test was not performed for the distributions in Table 1 because it is not a valid test when expected cell frequency is below 5 in many of the cases.[9] Comparing the columns of percentages, however, shows that even in Table 1 the distributions of age in the two samples are quite different. In Tables 2 through 4, the Chi-square test leads to rejection of the null hypothesis of independence of variables. This means that the distributions of age in the samples are quite different. Thus, the conclusion can be drawn that the existing anthropometric data base does not accurately reflect the age distribution of the current active duty force.

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* The current force is represented in all analyses in this report by the December 31, 1983, figures. They are labelled "1983 Army" in tables. The source is Military Personnel Center.[8]

TABLE 1. Age Comparison - Male Officers: 1966 Survey/1983 Army.

Age	1966 Survey	%	1983 Army	%
16-20	4	3.5	46	0.0
21-25	44	38.3	14,523	15.3
26-30	26	22.6	23,325	24.6
31-35	29	25.2	21,656	22.9
36-40	11	9.6	19,048	20.1
41-45	0	0.0	10,061	10.6
46-50	1	0.9	4,556	4.8
50+	0	0.0	1,418	1.5
Total	115	100.1	94,633	99.8

TABLE 2. Age Comparison - Male Enlisted: 1966 Survey/1983 Army.

Age	1966 Survey	%	1983 Army	%
16-20	3,619	55.1	146,281	24.3
21-25	2,365	36.0	217,465	36.1
26-30	232	3.5	113,141	18.8
31-35	149	2.3	67,001	11.1
36-40	129	2.0	40,140	6.7
41-45	44	0.7	14,140	2.3
46-50	16	0.2	3,391	0.6
50+	15	0.2	484	0.1
Total	6,569	100.0	602,043	100.0

$X^2 = 4101.868$
$P = 0.0001$

TABLE 3. Age Comparison - Female Officers: 1977 Survey/1983 Army.

Age	1977 Survey	%	1983 Army	%
16-20	0	0	0	0
21-25	221	64.2	2,621	27.6
26-30	67	19.5	3,293	34.7
31-35	19	5.5	2,047	21.6
36-40	16	4.7	951	10.0
41-45	8	2.3	366	3.9
46-50	11	3.2	124	1.3
50+	2	0.6	87	0.9
Total	344	100.0	9,489	100.0

$X^2 = 238.111$
$P = 0.0001$

NOTE: Chi-square calculated omitting the 16-20 year-olds.

TABLE 4. Age Comparison - Female Enlisted: 1977 Survey/1983 Army.

Age	1977 Survey	%	1983 Army	%
16-20	499	50.6	16,009	24.0
21-25	313	31.7	30,216	45.4
26-30	118	12.0	13,623	20.5
31-35	46	4.7	4,882	7.3
36-40	6	0.6	1,515	2.3
41-45	3	0.3	295	0.4
46-50	1	0.1	47	0.0
50+	0	0.0	12	0.0
Total	986	100.0	66,599	99.9

$X^2 = 377.382$
$P = 0.0001$

Because of the differences in age distribution between the current force and the anthropometric data base, serious adverse consequences could result from using the current data base as if it actually represented the current force. In the development of tariffs for Army clothing, for example, several body circumferences are important key dimensions. To the extent that these body dimensions are affected by the age of the subject,[6] it is possible that using the current data base would result in tariffs which are too heavily weighted in the smaller sizes. While the individual soldier could simply request a larger size to get adequate fit, such a situation on as large a scale as military procurement could result in serious distribution problems.

It is interesting to consider whether the anthropometric data base age distributions accurately represented the age distributions of the active duty forces that were current in 1966 and 1977. It is, unfortunately, no longer possible to obtain records of Army personnel from 1966. The records from 1977 remain, however, so it is possible to compare the age distribution in the 1977 survey of Army women with the female active duty force in 1977.[10] These data are compared in Tables 5 (for officers) and 6 (for enlisted). Note that the Chi-square levels indicate rejection of the null hypothesis of independence of variables -- that is, the age distributions are different for the two groups. This is not to suggest that the survey of 1977 was improperly done. On the contrary, it simply demonstrates that where age is not a part of the sampling strategy, as it was not in 1977, then the age distribution of the resulting survey data does not necessarily represent the age distribution of the total population. As indicated in the discussion of the male age distributions above, the use of a data base with a nonrepresentative age distribution can have a negative outcome in the practical matter of tariffs for Army clothing. Because age changes affect body proportions as well as body size,[6] the consequences for fit are the most critical.

TABLE 5. Age Comparison - Female Officers: 1977 Survey/1977 Army.

Age	1977 Army Survey	%	1977 Army Females	%
16-20	0	0.0	9	0.2
21-25	221	64.2	2,047	38.7
26-30	67	19.5	1,839	34.7
31-35	19	5.5	614	11.6
36-40	16	4.7	346	6.5
41-45	8	2.3	190	3.6
46-50	11	3.2	170	3.2
50+	2	0.6	79	1.5
Total	344	100.0	5,294	100.0

$X^2 = 91.106$
$P = 0.0001$

TABLE 6. Age Comparison - Female Enlisted: 1977 Survey/1977 Army.

	1977 Army Survey	%	1977 Army Females	%
16-20	499	50.6	15,055	33.6
21-25	313	31.7	21,203	47.4
26-30	118	12.0	6,010	13.4
31-35	46	4.7	1,783	4.0
36-40	6	0.6	509	1.1
41-45	3	0.3	131	0.3
46-50	1	0.1	58	0.1
50+	0	0.0	18	0.0
Total	986	100.0	44,767	99.9

$X^2 = 137.363$
$P = 0.0001$

It is not possible to compare the age distribution of the existing anthropometric data base with the projections of the age distribution of the active duty force in the 1990s since specific projections are not available. One could probably assume, however, that the existing data base is unlikely to be adequately representative of the 1990s Army, given the overrepresentation of the younger age groups in the sample. The future age distribution of the Army is dependent on the age of the personnel currently in the force, as well as on the current and future recruiting priorities of the Army. Unless there is a sudden heavy emphasis on recruiting very young individuals, the existing data base is unlikely to be representative of the active duty force any time in the foreseeable future.

Sex

A comparison of the existing data base and the current active duty force on the basis of sex is artificial and would produce misleading results. With the exception of the few males measured in connection with the 1977 survey of Army women,[7] the anthropometric surveys of the Army, and all other military surveys in the U.S. as well, have operated essentially independently with regard to sex. Until recently, clothing designs were sex-specific and females did not require combat gear or personal protective equipment. These conditions are changing, however, and there is now a need for field clothing and equipment that will fit both males and females. This need will be best met by a survey in which both men and women are measured with comparable techniques.

For the purposes of a future Army anthropometric survey, it is useful to compare the sex ratio of the current active duty force with that of the projected Army of the 1990s. While a specific targeted ratio is not available, the ceiling for females in the 1990 Army has been set at 13%.[11] If it is

assumed that the ceiling is reached, and that the total size of the Army is unchanged from current figures, then a Chi-square analysis (Table 7) shows that the null hypothesis of independence of variables (sex, year) should be rejected. The test shows that the sex ratio of the current Army is very different from the projected sex ratio of the 1990s. However, this analysis is based on a ceiling figure, which may be reached much later than the 1990s or may never be reached.

TABLE 7. Sex Distribution of Current and Projected Army.

	1983 Army	%	1990 Projection	%
Males	697,705	90.2	673,325	87.0
Females	76,232	9.8	100,612	13.0
Total	773,937	100.0	773,937	100.0

$X^2 = 3794.61$
$P = 0.0001$

Race

Probably the greatest changes in the composition of the Army are taking place with respect to the racial composition of the force. In the 1966 survey of Army males, subjects were not classified on the basis of race. Instead, subjects were asked to select their national extractions from a list of 47 categories. These categories have been combined, for the purposes of this report, into racial groups approximating the classification of the current active duty force. The list of national extractions and their grouping into racial categories is presented in Appendix A.

The racial classification of the current forces does not include a race "Hispanic." Rather, a person of any race can be "of Hispanic origin." While this system is probably more true to the biological and social meanings of "race" and "ethnic group" in the U.S., it is analytically difficult and not comparable with past data collection schemes. Thus, for this report, persons of Hispanic origin in the 1966 survey of Army males have been reclassified as a "Hispanic" race. This was done by collecting Whites of Hispanic origin, Blacks of Hispanic origin, and so on, into a race category Hispanic. These individuals were removed from their former racial categories so that the total of all individuals remains unchanged.

The racial composition of the 1966 survey of Army males is compared to the male active duty force in Table 8. This table shows that Blacks are proportionately underrepresented in the existing anthropometric data base, relative to the active duty force. Likewise, Whites are overrepresented in the anthropometric data base. The other racial groups are, if not identical to

TABLE 8. Racial Composition of Males: 1966 Survey/1983 Army.

	1966 Survey	%	1983 Army	%
White	5,107	76.4	458,456	65.7
Black	972	14.5	188,539	27.0
Hispanic	330	4.9	27,009	3.9
Am. Indian	51	0.8	2,018	0.3
Asian	44	0.7	1,136	0.2
Other	178	2.7	20,547	2.9
Total	6,682	100.0	697,705	100.0

$X^2 = 693.150$
$P = 0.0001$

the active duty force proportions, at least distributed in approximately comparable proportions. Nevertheless, the White/Black discrepancies account for the significant Chi-square value, which allows rejection of the null hypothesis of independence of variables.

Some reworking of racial classification is required of the female data sets before comparisons can be made. In the 1977 survey of Army women, race was not asked of the subject, but rather was visually assessed by team members. Because of that, it was felt that any classification other than Black/Whites/Asian/Other was more discriminating than the data justified. It is now desirable, however, to have data on Hispanics because of the increasing proportion of that group in the Army. Therefore, the original data sheets from the 1977 women's survey were examined, those individuals with an Hispanic surname were extracted and assembled, and a new Hispanic category was formed. This is an imperfect method, but the only means available to assess the representativeness of the existing data base with respect to race. It was also necessary to collapse American Indians in the active duty force into the category "Other", because this category was not recognized during the 1977 survey, and there was no post facto method of identifying American Indians.

Females from the 1977 survey and the current active duty force are compared, with respect to racial distribution, in Table 9. The results of the Chi-square test lead to rejection of the null hypothesis of independence of variables, showing that the racial composition of the 1977 survey is different from that of the current Army females. It is interesting to note that, even with the imperfect method of identifying Hispanics, there are slightly more Hispanic females in the anthropometric data base than there are in the current active duty force. As in the case of the males, the Whites are overrepresented in the existing data base relative to Blacks.

TABLE 9. Racial Composition of Females: 1977 Survey/1983 Army.

	1977 Survey	%	1983 Army	%
White	937	70.5	42,179	55.3
Black	296	22.3	29,436	38.6
Hispanic	39	2.9	2,042	2.7
Asian	22	1.7	232	0.3
Other	36	2.7	2,343	3.1
TOTAL	1,330	100.1	76,232	100.0

$X^2 = 217.252$
$P = 0.0001$

The important uses to which an Army anthropometric data base are put (e.g., anthropometric sizing and tariffing) can be adversely affected when the data base is not racially representative of the actual user population. In the final section of this report race is demonstrated to have an important influence on many anthropometric variables. When the race distribution of the data base is not representative of the user population, then items of clothing or personal protective equipment designed to the data base will not adequately clothe or protect the intended user population (see pages 30 to 34). Problems would be particularly noticed in the lengths of trousers and sleeves, and in protective equipment for the face.

Once again, it is interesting to compare the anthropometric surveys with the actual active duty force at the time the survey was conducted. This is not possible for the males because 1966 predates the period for which records are kept. It is possible to compare the racial distribution of the 1977 anthropometric survey females with the females from the active duty force in 1977. Here, the racial categories as defined by the Army in 1977 were White/Black/Hispanic/Other. Therefore, the Asians from the 1977 anthropometric survey were lumped with "Other" for this comparison. Both officers and enlisted are compared in Table 10. Although the results of the Chi-square test lead to rejection of the null hypothesis of independence of variables for both officers and enlisted, technically showing that the racial distributions are different, the 1977 survey does in fact include quite a reasonable representation of the racial distribution at that time. This can be verified by examination of the percent columns in Table 10. It is only when the 1977 survey is compared with the current racial distribution that it is not particularly representative (Table 9).

The Army Long Range Planning System has projections about the racial composition of the Army in the 1990s, although it does not provide these data broken down by rank or sex.[11] These figures are projections only, and any analyses of the data must be viewed with that in mind. The comparison is presented in Table 11. Note that the proportion of Whites is expected to decline and the proportion of Hispanics is expected to increase relative to the 1983 figures. If these projections prove accurate, then the existing data base

TABLE 10. Racial Composition of Females in 1977: Officers and Enlisted.

OFFICERS	1977 Survey	%	1977 Army Females	%
White	292	84.9	4,612	87.1
Black	28	8.1	474	9.0
Hispanic	5	1.5	105	2.0
Other	19	5.5	103	2.0
TOTAL	344	100.0	5,294	100.1

$X^2 = 19.997$
$P = 0.0002$

ENLISTED	1977 Survey	%	1977 Army Females	%
White	645	65.1	31,299	69.9
Black	268	27.0	10,958	24.5
Hispanic	34	3.4	1,630	3.6
Other	44	4.4	880	2.0
TOTAL	991	99.9	44,767	100.0

$X^2 = 35.351$
$P = 0.0001$

TABLE 11. Racial Composition of U.S. Army: Total Force - 1983 Army/1990 Projection.

	1983 Army (%)	1990 Projection * (%)
White	64.69	58.44
Black	28.16	28.16
Hispanic	3.75	10.00
Other	3.39	3.39
TOTAL	99.99	99.99

* Projected figures.
Source: Army Long Range Planning System.[11]

for anthropometry, with its high proportion of Whites, will not adequately represent the racial distribution of the active duty force of the 1990s.

To summarize the results of the analyses of racial distribution, the male anthropometric survey may or may not have been racially representative of the Army in 1966. It is no longer possible to determine this. The racial composition of the 1977 anthropometric survey was demonstrably representative of the females in the Army in 1977. However, the existing anthropometric data base for males and for females is not representative of the racial composition of the current active duty force. If the Army's projections about the racial composition of the Army in the 1990s prove accurate, even roughly, the existing data base will be even less representative of the Army at that time.

Summary of Specific Comparisons

The demographic comparisons presented in this section suggest that for the variables considered--age, sex, and race--the existing anthropometric data base does not well represent the current active duty force. This should not be taken to mean that the surveys were inappropriately conducted; it means, rather, that the changing population of the Army in the 19 and 8 years, respectively, since the male and the female surveys were conducted, has rendered the demographic data no longer representative of the current population.

It is difficult to foresee the future, particularly in the case of Army demographics, because the demographic composition of the Army is influenced by many factors. Among these are: recruiting priorities, the state of the national economy, international political tensions, and demographic changes in the U.S. population, the pool from which Army personnel are ultimately drawn. Nevertheless, some limited projections can be made. In particular, it seems probable that the Army's demographic composition will continue to change in precisely those directions in which it now differs most from the existing anthropometric data base. Thus, any differences between the data base and the active duty force are likely to become larger rather than smaller. To the extent that anthropometric variables are influenced by demographic factors (to be discussed below), it may be unwise to make anthropometric generalizations about the current or future Army based on the data from the existing anthropometric data base.

LONG-TERM DEMOGRAPHIC TRENDS

It is useful to examine the apparent changes in the demographic composition of the Army in the context of similar changes in the U.S. population as a whole, as well as in other U.S. military populations. Unfortunately, no data are now available on the demographic composition of the Army in the years preceding 1971. The demographic changes in the Army from 1971 to 1983, the most recent year for which data are available, will be compared for race and age to the U.S. population from the 1970[12] and 1980[13] censuses. Race was examined in the U.S. population from 1900 to present, but comparative Army data are unavailable over a similar time period.

Age

Changes in age in the last decade in the U.S. and in the last 12 years for the Army are compared in Tables 12 and 13, for males and for females, respectively. The age intervals, ranging from 16 to 55 for the Army and from 15 to 54 for the U.S. population, were selected because the age range includes the vast majority of Army personnel. Only a handful of individuals are not within those ages for the Army (0.03% of the 1983 males, for example). Ages 15 to 54 constitute only about half of the U.S. population in 1970 to 1980. Nevertheless, the age intervals were selected because it is of interest to determine if the changes occurring in the Army at those age intervals are reflective of those occurring in the general population, or if the Army is changing independently of the population. (Note that the 5-year increments, 15 to 19 etc., for the census, and 16 to 20 etc., for the Army, are not identical. This discrepancy is unavoidable because these are the intervals used by the Census Bureau and the Army, respectively, but the 1-year offset is not expected to produce analytic distortions.) The material from Tables 12 and 13 is graphically illustrated in Figures 1 and 2. For the males (Table 12 and Figure 1), it is clear first that the age distribution in the Army, for both the 1970s (1970, 1971) and the 1980s (1980,1983), is very different from that in the U.S. population. This is a function of heavy recruitment of young individuals and, in the case of 1971, the draft which selected primarily young individuals. The availability of attractive retirement programs after 20 years' service accounts for much of the decline in proportion after the age of 38 or 39.

A more useful comparison, however, is to examine the changes in age distribution between the Army 1971 and the Army 1983, and compare those changes to the changes occurring in the U.S. male population between the two census years. It is quite evident, particularly from the graphic display in Figure 1, that the age distribution of the Army is shifting to the right; that is, the mean age of the Army increased during the 12 years between 1971 and 1983. Conversely, for the census figures, the male population is generally younger in 1980 than it was in 1970. Caution is advised here. The total U.S. male population is actually aging. However, for the segment of the U.S. male population that bears comparison to the Army (i.e., males aged 15 to 54) the 1980 group is predominantly younger than the 1970 group.

The female comparisons (Table 13 and Figure 2) indicate that the pattern of change is similar, although not identical to that of the males. Specifically, the difference between males and females is in the individuals over the age of 40. For males, the 1971 Army and 1983 Army are fairly close in the proportions of individuals at age 40, and at age 44 there are no differences. For males in the U.S. population, that same age interval is characterized by a steady proportion of about 11% in 1970 and about 9% in 1980. Females show the same pattern for U.S. population figures, specifically the steady proportions of about 11 and 9%. However, the female Army personnel show a pattern very different from the Army male pattern. In the 1971 Army more of the women are over 40 than in the 1983 Army. Between 1971 and 1983, the number of females in the Army increased from 15,863 to 76,074. Because the increase in female recruits occurs at the lower end of the age distribution, the effect is to increase the total number of women while decreasing the proportional representation of older individuals.

TABLE 12. Changes in Age Distribution: Males.

Age (yrs)	U.S. Census 1970	Percent of Males 15-54	U.S. Census 1980	Percent of Males 15-54
15-19	9,716,327	18.66	10,755,409	16.97
20-24	7,753,863	14.89	10,663,231	16.82
25-29	6,572,273	12.62	9,705,107	15.31
30-34	5,595,530	10.74	8,676,796	13.69
35-39	5,440,065	10.45	6,861,509	10.83
40-44	5,828,633	11.19	5,708,210	9.01
45-49	5,832,820	11.20	5,388,249	8.50
50-54	5,339,439	10.25	5,620,670	8.87
TOTAL 15-54	52,078,950	100.00	63,379,181	100.00
% Males All Ages	52.66%		57.59%	

Age (yrs)	U.S. Army 1971	Percent of Males 16-55	U.S. Army 1983	Percent of Males 16-55
16-20	330,388	30.75	146,327	21.01
21-25	446,745	41.58	231,988	33.31
26-30	115,217	10.72	136,466	19.59
31-35	71,790	6.68	88,657	12.73
36-40	60,857	5.66	59,188	8.50
41-45	34,729	3.23	24,201	3.47
46-50	10,816	1.01	7,947	1.14
51-55	3,829	0.36	1,667	0.24
TOTAL 16-55	1,074,371	99.99	696,441	99.99
% Males All Ages	99.94%		99.97%	

TABLE 13. Changes in Age Distribution: Females.

Age (yrs)	U.S. Census 1970	Percent of Females 15-54	U.S. Census 1980	Percent of Females 15-54
15-19	9,480,843	17.44	10,412,715	16.11
20-24	8,351,006	15.36	10,655,473	16.49
25-29	6,823,213	12.55	9,815,812	15.19
30-34	5,854,931	10.77	8,884,124	13.75
35-39	5,710,119	10.50	7,103,793	10.99
40-44	6,154,004	11.32	5,961,198	9.22
45-49	6,250,413	11.50	5,701,506	8.82
50-54	5,735,821	10.55	6,089,362	9.42
TOTAL 15-54	54,360,350	99.99	64,623,983	99.99
% Females All Ages	52.11%		48.61%	

Age (yrs)	U.S. Army 1971	Percent of Females 16-55	U.S. Army 1983	Percent of Females 16-55
16-20	5,443	34.31	16,009	21.04
21-25	6,324	39.87	32,837	43.16
26-30	1,702	10.73	16,916	22.24
31-35	782	4.93	6,929	9.11
36-40	545	3.44	2,466	3.24
41-45	580	3.66	661	0.87
46-50	381	2.40	171	0.22
51-55	106	0.67	85	0.11
TOTAL 16-65	15,863	100.01	76,074	99.99
% Females All Ages	99.96%		99.98%	

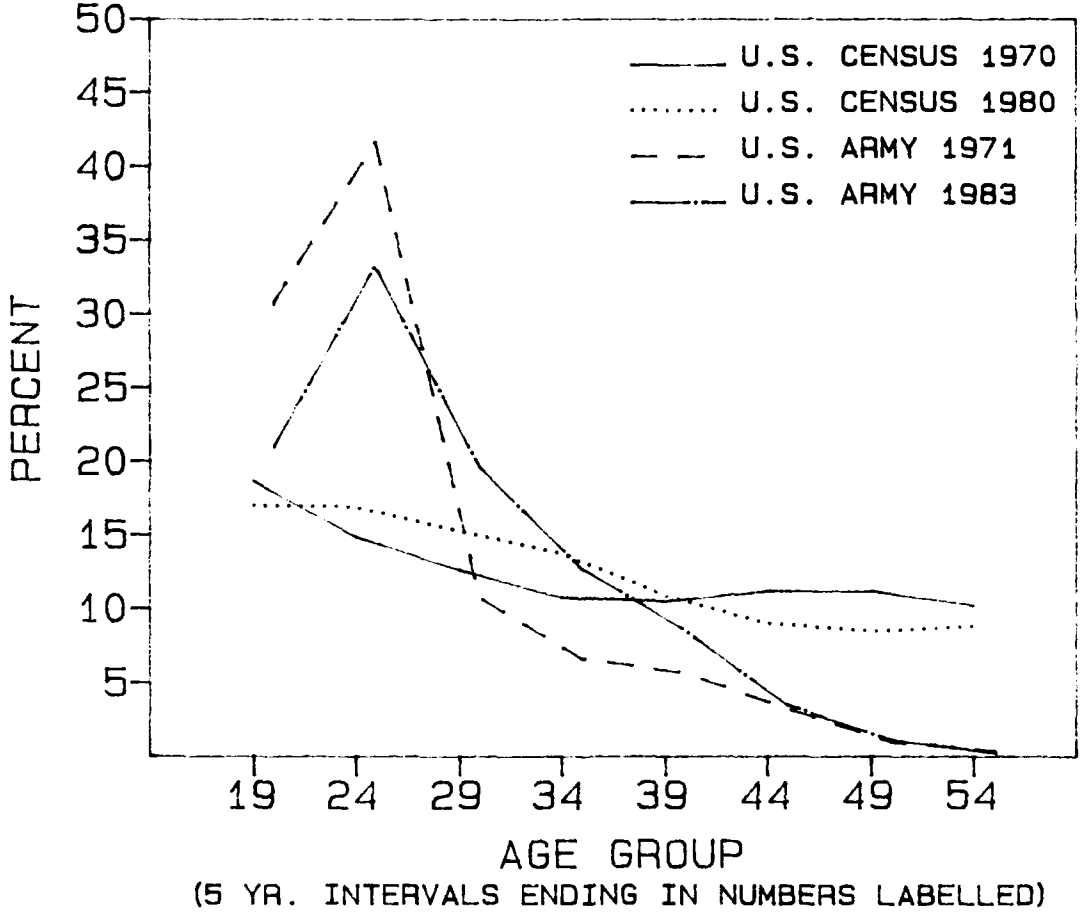

Figure 1. Changes in age distribution: U.S. Army and U.S. Census (males).

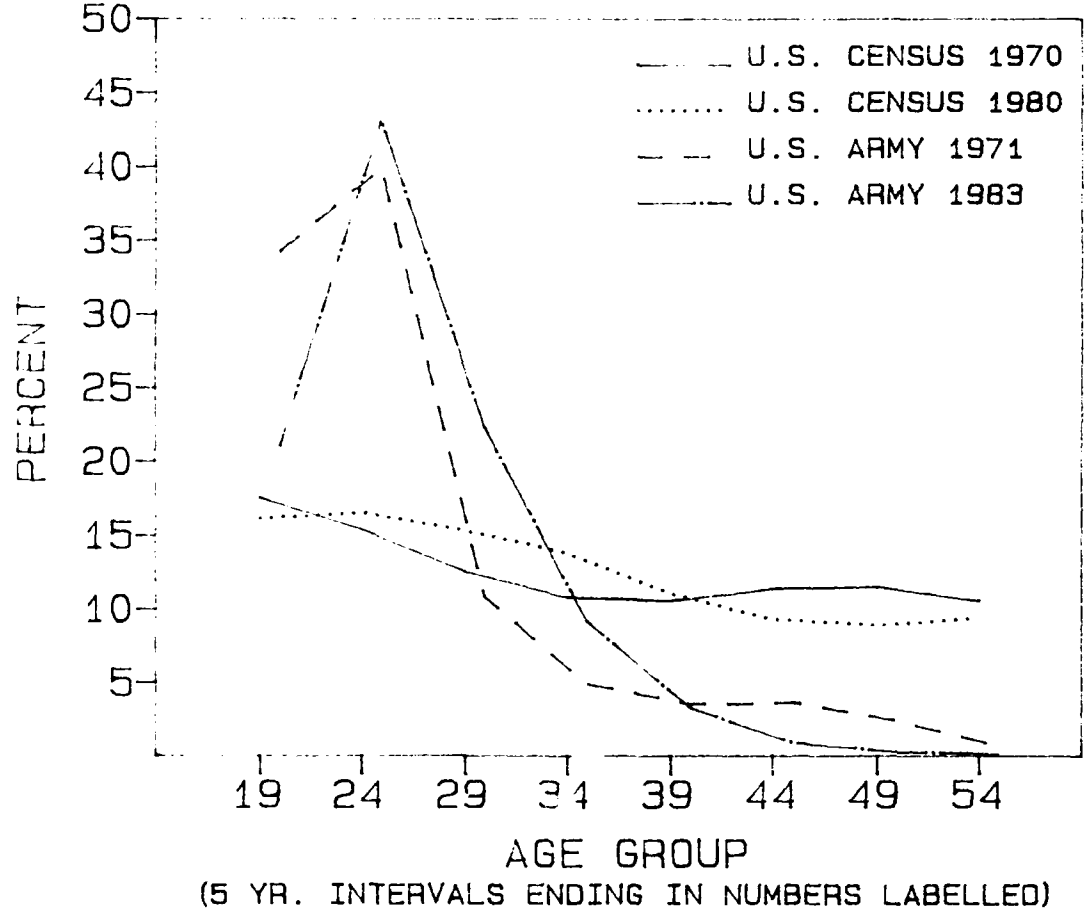

Figure 2. Changes in age distribution: U.S. Army and U.S. Census (females).

Although it is apparent that changes are taking place in the age distribution in both the U.S. population and in the Army, it is not clear from 10 or 12 year intervals whether these are part of a continuing long-term trend, an aberration in some other long-term trend, or part of a series of completely random fluctuations in age distribution. It is clear, however, that it is not easy to predict age changes in the Army from examining age changes in the U.S. population.

Sex

It was noted in an earlier section that sexually representative anthropometric surveys were not done in the past. Each survey was designed for one sex only. It is also true that the Army, in its recruitment strategies, does not attempt to represent the sex distribution of individuals in the general U.S. population, as can be seen in Table 14.

TABLE 14. Sex Distribution (%) of the Army and the U.S. Population.

1970			1980	
Males	Females		Males	Females
48.66	51.34	U.S. Population	48.58	51.42
98.54	1.46	Army *	90.15	9.85

* Note that the actual years for the Army are 1971 and 1983.

The sexual composition of the U.S. population has remained virtually unchanged over the last decade, whereas the proportion of females in the Army has increased nearly sevenfold. It is clear that, as with age, one cannot predict changes in the sexual composition of the Army from changes (or lack of changes) in the sexual composition of the U.S. population. Other factors are far more important in determining the proportion of women who enter the military.

Race

Comparing racial trends over a long period is difficult because the definition of race changes with time. The result of this is that classification schemes differ from generation to generation. Nevertheless, the Census Bureau recently published a racial breakdown of the U.S. population for every census since 1900.[13] Some of these data are reproduced in Table 15, where the racial composition is expressed as a percent of the total. Males and females are treated separately and together. These data are illustrated graphically in Figures 3 through 8. Note that Figures 3 and 5 illustrate primarily the proportion of Blacks and Whites. All other races are combined. In Figures 4 and 6 all races except Blacks and Whites are shown. This method of illustration was chosen so that an enlarged scale could be used for the races with the lowest frequencies. Note the relatively constant proportions for all races from 1900 through 1960. In 1970 there is a slight increase in American

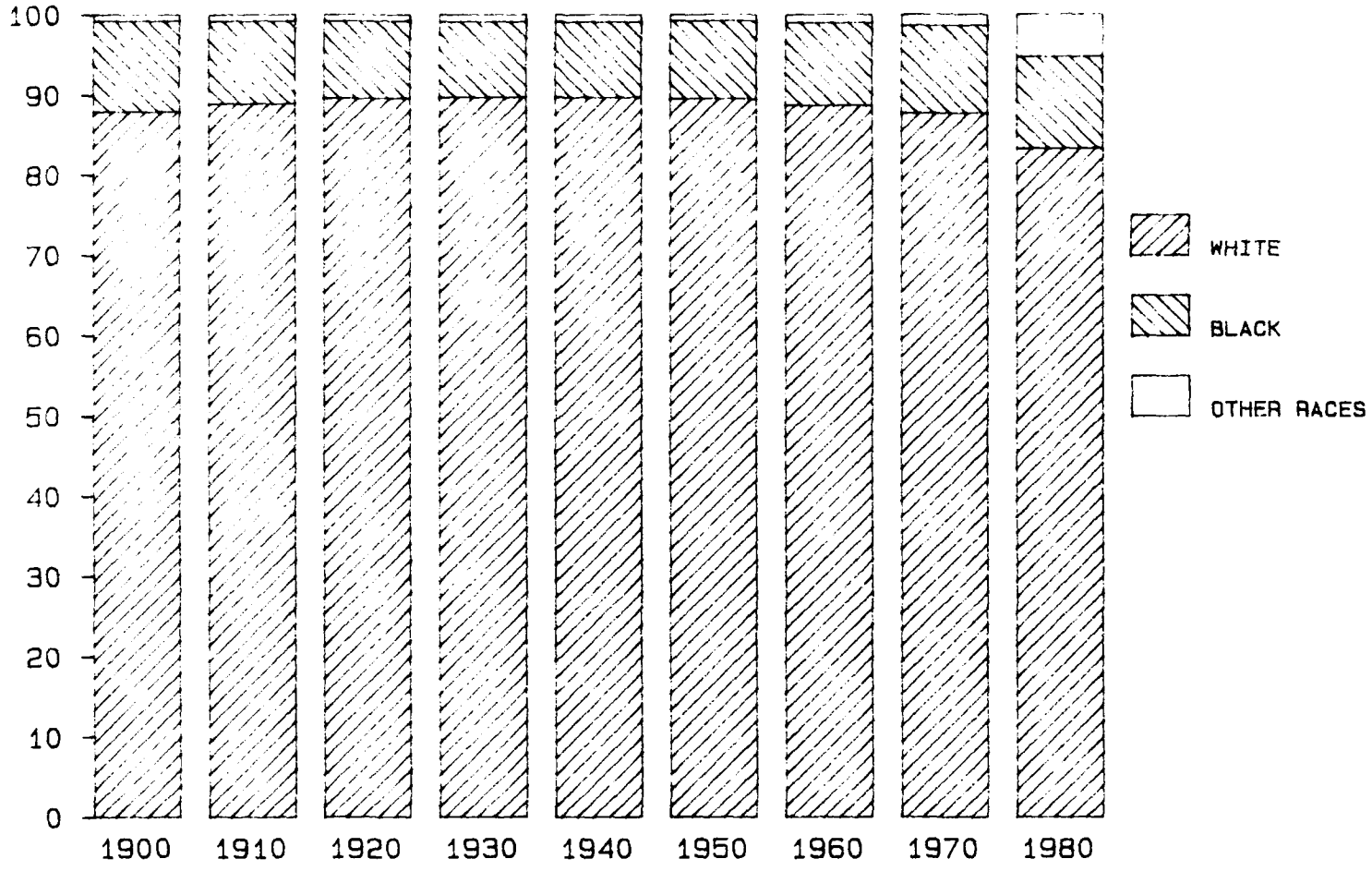

Figure 3. Percent race in U.S. male populations 1900 to 1980: White, Black and other races.

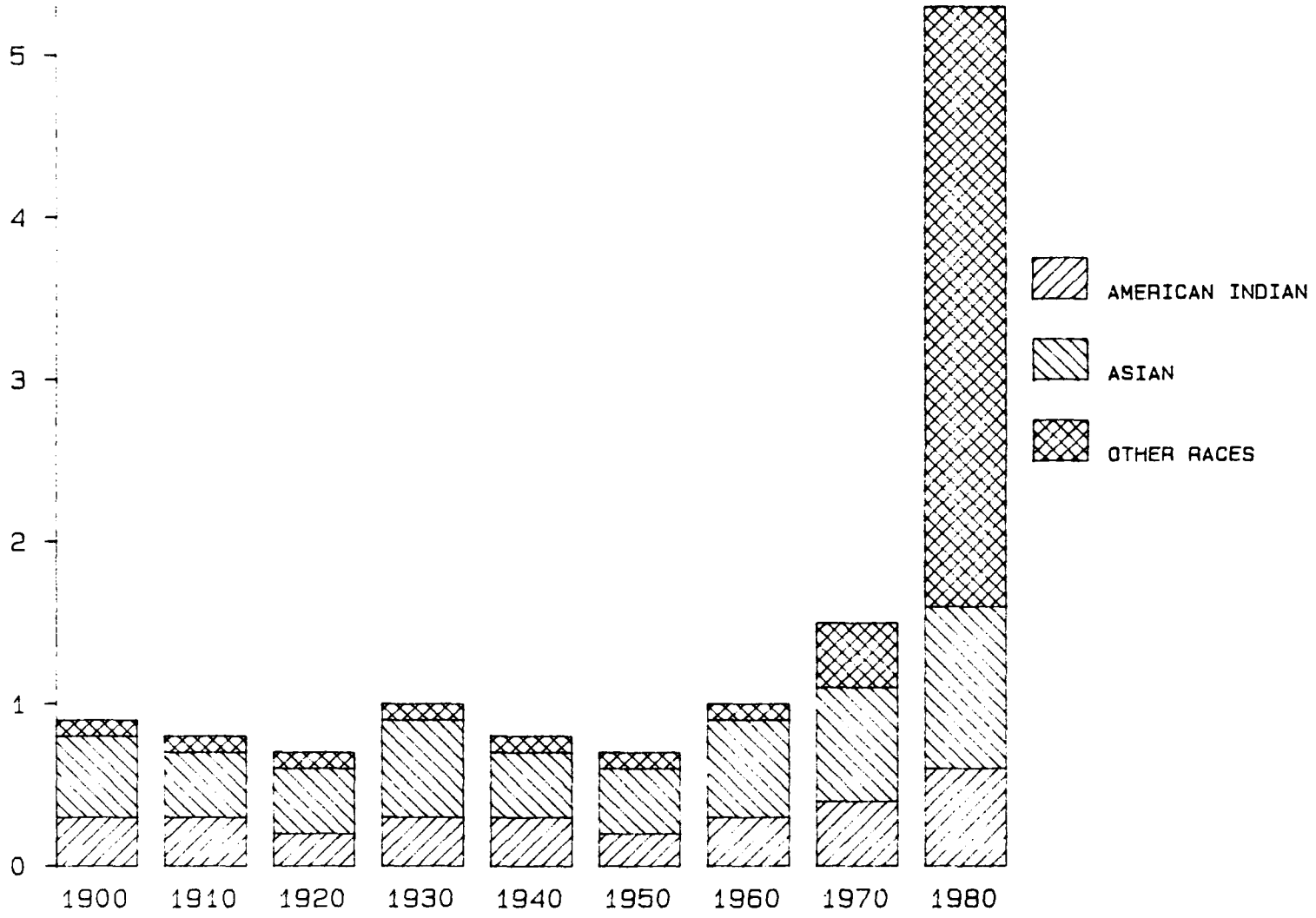

Figure 4. Percent race in U.S. male population 1900 to 1980: American Indian, Asian, and other races.

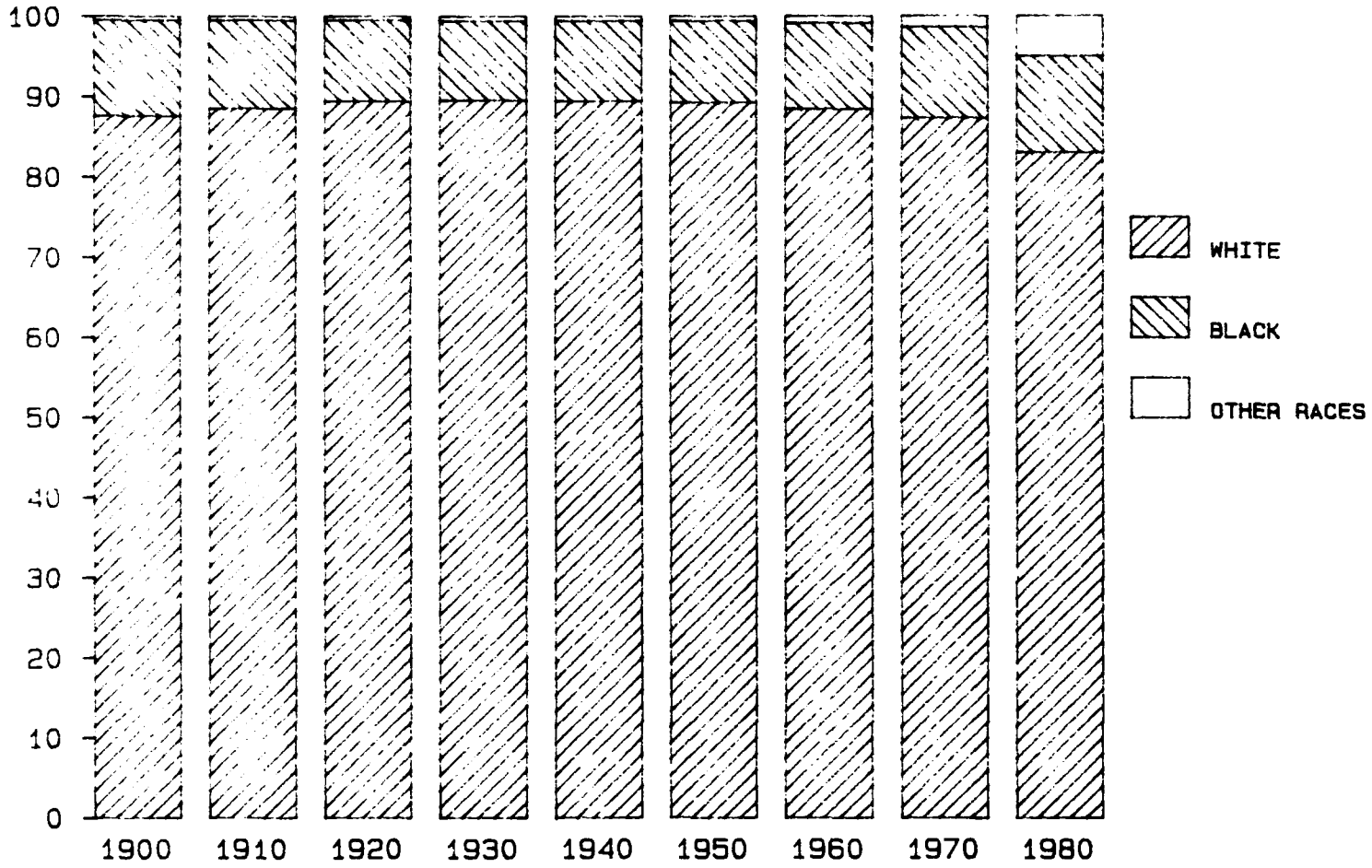

Figure 5. Percent race in U.S. female population 1900 to 1980: White, Black, and other races.

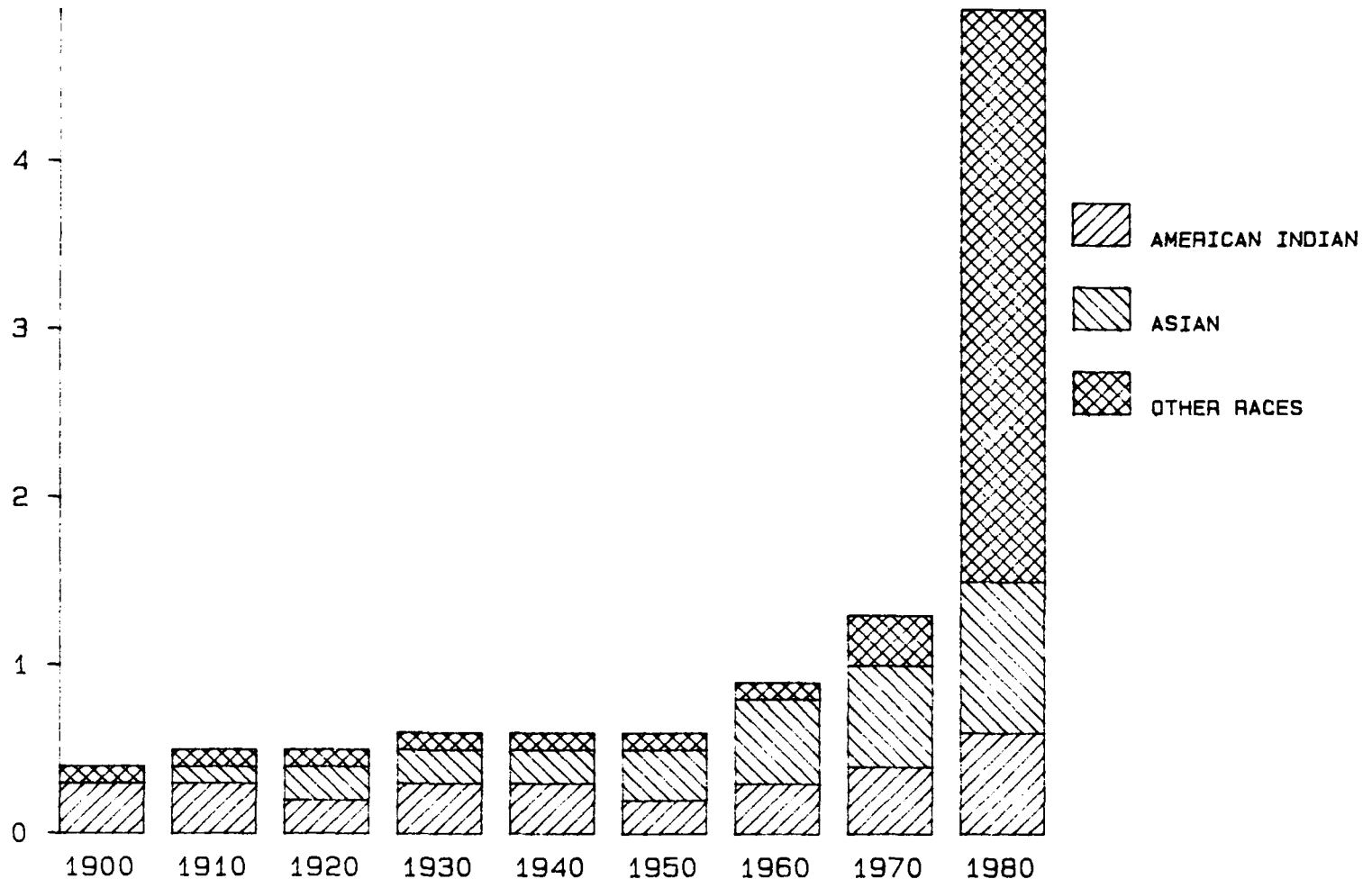

Figure 6. Percent race in U.S. female population 1900 to 1980: American Indian, Asian, and other races.

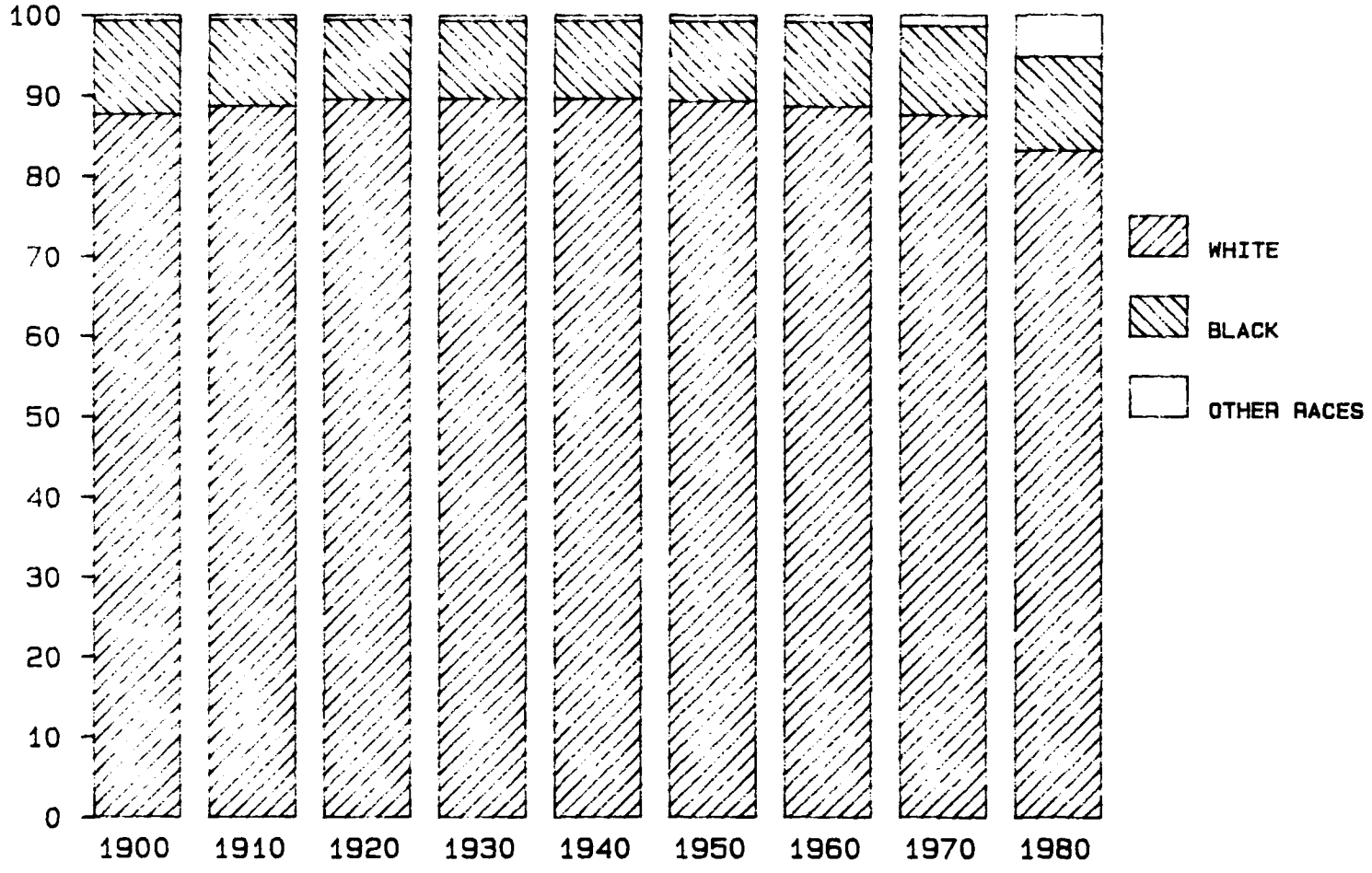

Figure 7. Percent race in total U.S. population 1900 to 1980: White, Black, and other races.

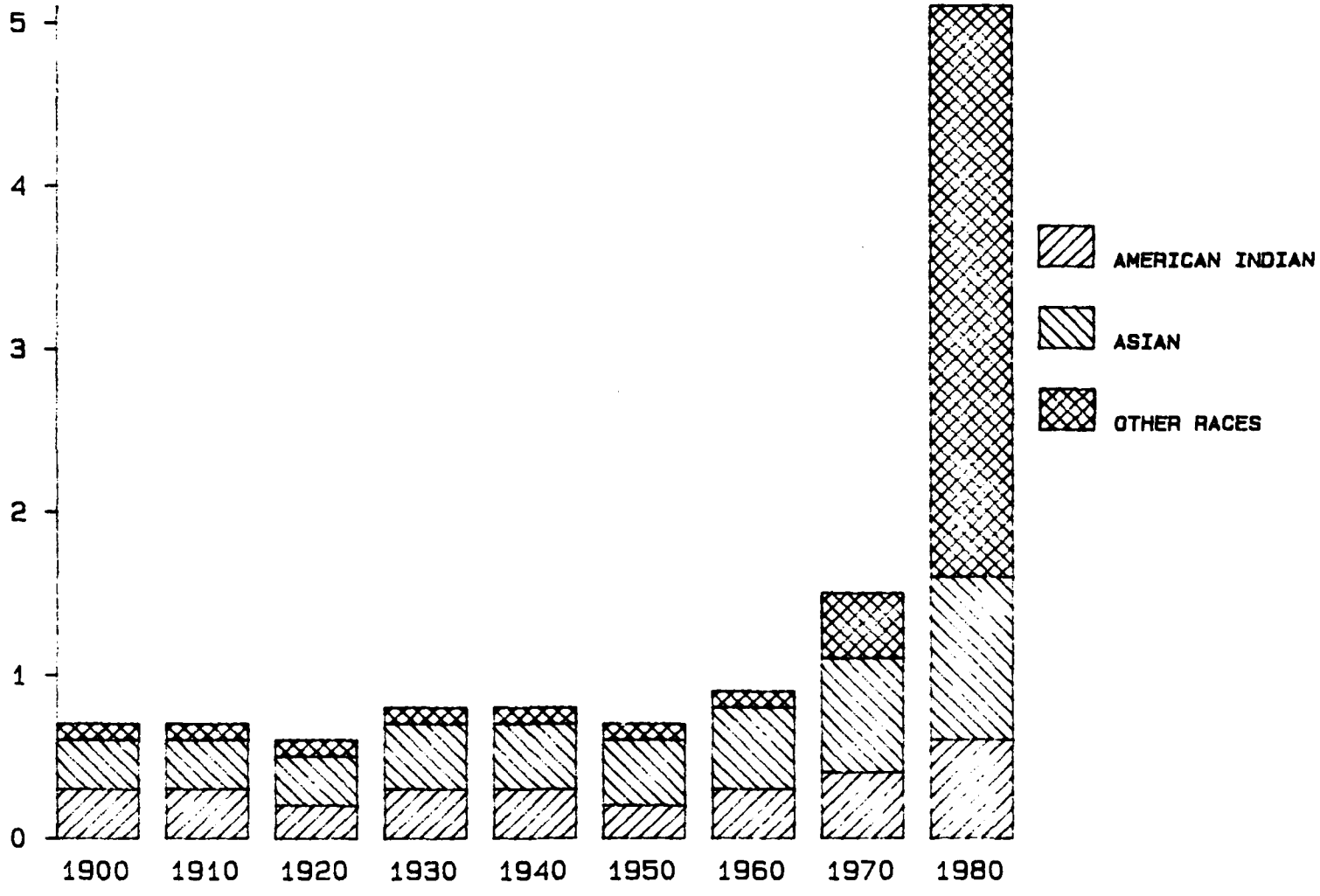

Figure 8. Percent race in total U.S. population 1900 to 1980: American Indian, Asian, and other races.

TABLE 15. Racial Composition (%) U.S. Census 1900-1980.*

MALES	1900	1910	1920	1930	1940	1950	1960	1970	1980
White	87.9	88.9	89.6	89.7	89.7	89.5	88.7	87.7	83.3
Black	11.3	10.3	9.6	9.4	9.4	9.7	10.3	10.9	11.4
Amer. Indian	0.3	0.3	0.2	0.3	0.3	0.2	0.3	0.4	0.6
Asian	0.0	0.4	0.4	0.6	0.4	0.4	0.6	0.7	1.0
Other	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	3.7
FEMALES									
White	87.6	88.5	89.4	89.5	89.4	89.2	88.4	87.3	83.0
Black	11.9	11.0	10.1	9.9	10.0	10.2	10.7	11.3	12.0
Amer. Indian	0.3	0.3	0.2	0.3	0.3	0.2	0.3	0.4	0.6
Asian	-	0.1	0.2	0.2	0.2	0.3	0.5	0.6	0.9
Other	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	3.4
TOTAL									
White	87.7	88.7	89.5	89.6	89.6	89.3	88.6	87.5	83.1
Black	11.6	10.7	9.9	9.7	9.7	9.9	10.5	11.1	11.7
Am. Indian	0.3	0.3	0.2	0.3	0.3	0.2	0.3	0.4	0.6
Asian	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.7	1.0
Other	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	3.5

* Source: Census of the Population, 1980, Bureau of the Census.[13]

Indians, Asians and "Other". In 1980, however, there is a substantial increase in "Other" and a continued increase in American Indians and Asians.

The data from Table 15 and Figures 7 and 8 suggest a rather dramatic change in the U.S. population between census years 1970 and 1980. A closer examination of some of those groups can be found in Table 16. In this table, selected racial groups from Table 15 for just the last two census years are shown. Added to Blacks and Whites in Table 16 are persons of Hispanic origin. Hispanic individuals were not counted in any census until 1970. Therefore, they do not appear on Table 15. Further, the Bureau of the Census, like the Army, does not treat Hispanics as a race, but rather as an ethnic category that applies to a person of any race. Thus, in the raw numbers of Table 16, some of the Whites, Blacks and "Other" individuals are also counted among the persons of Hispanic origin.

Table 16 shows several interesting facets of the change in the U.S. population in the last decade. First, the largest change is in "Other" individuals. This is true for both males and females. Several factors may account for this dramatic increase: (1) an increase in immigration from Central and South America of individuals who do not consider themselves either White or American Indian; (2) an increase in immigration from the Middle East, where individuals

TABLE 16. U.S. Census Selected Groups by Year and Sex.

	1970	Percent[a]	1980	Percent[a]	Percent Change[b]	Percent Change in Proportion[c]
Race: Other Males	364,835	0.37	4,072,446	3.70	+1016.24	+900.00
Race: Other Females	355,685	0.34	3,961,013	3.40	+1013.63	+900.00
White Males	86,720,987	87.67	91,685,333	83.31	+5.72	-4.97
White Females	91,027,988	87.28	96,686,289	83.00	+6.22	-4.90
Black Males	10,748,316	10.87	12,519,189	11.38	+16.48	+4.69
Black Females	11,831,973	11.34	13,975,836	12.00	+18.12	+5.82
Spanish Origin Males	4,013,801	4.06	7,279,831	6.61	+81.37	+62.81
Spanish Origin Females	4,142,782	3.97	7,328,842	6.29	+76.91	+58.44

[a] Percent of total males or females, respectively.
[b] Calculated using n's from this table.
[c] Calculated using percent values from this table.

are not likely to consider themselves members of any of the other racial categories; or (3) a change in classification from 1970 (i.e., some individuals who considered themselves White in 1970 may now consider themselves "Other"). The last of these may be especially true of a number of ethnic groups that, in the 1970s, may have experienced a raising of ethnic consciousness and are no longer comfortable with a "White" label.

A second point that arises from examination of Table 16 is that, although White males and White females experienced an absolute increase in number from 1970 to 1980, the relative proportion of these two groups in the total population actually declined from 1970 to 1980. There is a similar pattern in Black males and Black females. Although Blacks did not decline in relative proportion, the increase in proportion was much smaller than the increase in actual numbers would indicate.

With a clear focus on the marked changes taking place in the U.S. population between 1970 and 1980, it is well for the purposes of this report to examine the changes in racial distribution taking place in the Army during this period. In Table 17, the racial composition of Army males is displayed with the U.S. Census data for the 1970 and 1980 time periods. Note that, as before, the years of the Army data (1971 and 1983) are slightly different from the census years (1970 and 1980). It is unlikely that this will have an important impact on the interpretation of the results. Note also that the Army data for 1971 have a racial classification scheme of White/Black/Other. The 1983 Army data, and the census data from both 1970 and 1980, have been collapsed into these categories for comparative purposes. The Army was roughly representative of the U.S. population in 1971. In 1983, however, the Army is no longer representative of the country's racial composition. Specifically, the Army has a much larger proportion of Blacks and a somewhat larger proportion of "Other" individuals than the U.S. population. Table 18 is a parallel display for females. Here again, the Army in 1971 was roughly representative of the racial distribution of the U.S. female population. By 1983, however, Whites are dramatically underrepresented in the active duty force and Blacks are correspondingly overrepresented.

TABLE 17. Changes in Racial Composition: Males.

	U.S. Census 1970		U.S. Census 1980	
		%		%
White	86,720,987	87.67	91,685,333	83.31
Black	10,748,316	10.87	12,519,189	11.38
Other	1,442,889	1.46	5,848,639	5.31

	U.S. Army 1971		U.S. Army 1983	
		%		%
White	948,068	86.20	458,456	65.71
Black	141,684	12.88	188,539	27.02
Other	10,156	0.92	50,710	7.27

TABLE 18. Changes in Racial Composition: Females.

	U.S. Census 1970		U.S. Census 1980	
		%		%
White	91,027,988	87.28	96,686,289	83.00
Black	11,831,973	11.34	13,975,836	12.00
Other	1,439,773	1.38	5,830,515	5.00

	U.S. Army 1971		U.S. Army 1983	
		%		%
White	14,172	84.49	42,179	55.33
Black	2,423	14.45	29,436	38.61
Other	178	1.06	4,617	6.06

Comparisons of the racial composition of the Army with those of the Air Force and the Navy are also of interest. Because the three services all draw from the same pool, differences among them in racial composition may reflect the results of recruiting practices as well as entrance requirements. Racial data for the three services are presented in Table 19. Two points can be made from examining the table. First, the racial distribution of the Army is quite different from that of the other two services. Second, the Navy and the Air Force come reasonably close to matching the distribution in the U.S. male population (Table 17). The female distributions in the Air Force and Navy are not as close to the U.S. females as are the male distributions, but they too are closer than the Army females.

Summary of Comparisons to U.S. Population

It was shown in the previous section that the existing anthropometric data base of Army men and women does not represent the current active duty force, primarily due to changes in the demographic characteristics of the Army. In this section, those changes occurring in the Army have been examined in the larger context of changes occurring in the U.S. population as a whole. The age of Army personnel appears to be increasing, while the U.S. population, in the segment that corresponds to the ages in the Army, is actually getting younger. The sex ratio in the general population is basically unchanging with the passage of time. In the Army, however, the sex ratio is undergoing a period of dramatic shift, with ever increasing numbers of females entering the military service. For changes in racial composition, the direction of changes in the Army is the same as the direction of changes in the U.S. population. The differences are in the magnitude of the change. The Army exhibits a much more dramatic reduction in the proportion of Whites, and a more dramatic increase in the proportion of "Other", than the U.S. population. The Army has also increased, more than the general population, in the proportion of Blacks.

These distinctions between the demographic secular trends in the Army and the trends in the U.S. population suggest that any projections for future demographic characterizations for the Army should be based on Army data and policy alone, and not on trends found in the U.S. population as a whole.

TABLE 19. Tri-Service Comparison of Racial Composition.

MALES

	Army[a]		Navy[b]		Air Force[c]	
	N	%	N	%	N	%
White	458,456	65.71	414,287	79.57	425,048	82.62
Black	188,539	27.02	58,870	11.31	75,083	14.59
Other	50,710	7.27	47,527	9.13	14,304	2.78
TOTAL	697,705	100.00	520,684	100.01	514,435	99.99

FEMALES

	Army[a]		Navy[b]		Air Force[c]	
	N	%	N	%	N	%
White	42,179	55.33	37,174	76.46	50,179	78.49
Black	29,436	38.61	8,409	17.30	11,818	18.49
Other	4,617	6.06	3,034	6.24	1,930	3.02
TOTAL	76,232	100.00	48,617	100.00	63,927	100.00

[a] Data as of 31 December 1983; source Military Personnel Center.[8]
[b] Data as of 31 December 1984; source courtesy Commander William Moroney, U.S.Navy.[14]
[c] Data as of 30 Sept 1982; source Air Force Magazine, May 1983.[15]

ANTHROPOMETRIC COMPARISONS

Short-Term Comparisons

When assessing the applicability of the existing anthropometric data base for the current active duty force of Army personnel, the anthropometric variables themselves are perhaps more important than the demographic variables presented in the previous sections. Because a major anthropometric survey is not conducted on an annual basis, there is no ready supply of anthropometric data for the current Army active duty force. The stature and the weight of officers in 1983 are available from medical records. It should be noted, however, that medical records are not as reliable as data from anthropometric surveys.[16] It is possible, at least, to compare these values with those in the existing anthropometric data base.[1,2] The comparisons are presented in Table 20. The usual way to compare arithmetic means statistically is by using a t-test, which tests the null hypothesis that there is no difference between the means. The t-statistic is calculated for male and female officers. The results are in Table 20. Note that the mean for stature of the 1983 male officers is 1.28 inches greater than the mean in 1966. The current officers are also 3.73 pounds heavier than their earlier counterparts. On the basis of the t-test, the null hypothesis of equal means is rejected for both variables.

TABLE 20. Stature and Weight Comparisons.

MALE OFFICERS

	1966 Survey			1983				
	$\bar{X}$	SD	n	$\bar{X}$	SD	N	F[a]	t[c]
Stature (in)	69.34	2.15	115	70.62	2.70	92,066	1.03[b]	3.307[b]
Weight (lb)	169.12	19.74	115	172.85	20.04	92,067	1.57[b]	2.207[b]

FEMALE OFFICERS

	1977 Survey			1983				
	$\bar{X}$	SD	n	$\bar{X}$	SD	N	F[a]	t[c]
Stature (in)	64.68	2.46	344	65.10	2.76	9,108	1.25[b]	0.413
Weight (lb)	132.28	18.72	344	130.36	16.29	9,107	1.32[b]	1.869

[a] F-test, testing equality of variance of two samples.

[b] Significant at the 0.05 level.

[c] Because F-tests led to rejection of H_o of equality of variance, the t was calculated under the assumption of unequal variances.

Note also, however, that the number of officers measured in the 1966 survey was quite small (115) and so may not accurately represent all the male officers in the Army at that time. However, the question here is whether the existing anthropometric data base is sufficient to represent the current active duty force of male officers in the Army. This comparison suggests that the current male officers are significantly larger than the data base officers.

The current female officers of the Army have a stature mean that is less than 0.5 inches greater than the 1977 survey females; the current female officers are just under 2 pounds lighter than the 1977 survey officers. However, the t-test shows that neither of these differences is significant. Specifically, the hypothesis that the means are the same cannot be rejected and thus it must be concluded that the female officers from the 1977 survey could adequately represent the current active duty force of female officers with respect to the mean values for stature and for weight.

Most design tasks do not make direct use of mean values for stature and weight. Other body dimensions and combinations of dimensions are usually more critical determinants of fit and function. As data do not exist for evaluating the applicability of the existing data base for describing the current active duty force on these other variables, inferences must be made from stature and weight data.

It has been demonstrated in previous sections that, with regard to demographic components, the existing data base is not representative of the

demographic makeup of the current force. Therefore, if it is shown that specific anthropometric variables are strongly influenced by demographic variables, it would support the conclusion that the existing data base does not well represent the current force for those variables.

One way of demonstrating the effect of age and race on specific anthropometric variables is to use analysis of variance. This technique tests the null hypothesis that group means are equal. The specific analyses here are two one-way analyses of variance. In the first analysis, the effect is racial group (such as Blacks, Whites, etc., for six groups). In the second, the effect is age group (such as 21-25, 26-30, and so on for seven groups). These analyses of variance were performed on all 70 anthropometric variables in the Army 1966 data base. A typical analysis of variance table is shown in Table 21.

TABLE 21. Analysis of Variance - Dependent Variable: Chest Circumference.

Sources of Variation	df[a]	Sum of Squares	Mean Square	F
Race	5	180325.84	36065.17	8.11[b]
Error	6648	29556909.77	4445.99	
Total	6653	29737235.61		

[a] degrees of freedom
[b] $P < .001$

These analyses of variance indicate that race is a significant determinant of mean value for all 70 variables at the 0.05 significance level. This means that, for each variable, the mean value is different for at least two of the racial groups. For age group, the analyses of variance lead to rejection of the null hypothesis, at 0.05, on 57 of the 70 variables. Thus, for those 57 variables, at least two of the age group means are different from each other. The analysis of variance results for all variables tested appear as Appendix B.

These analyses make a strong case for the effect of some demographic variables on anthropometric dimensions. Another demographic variable considered earlier in the report but not included in the analyses of variance is sex. This was not included because it is not necessary to demonstrate statistically that individuals of different sexes have different body sizes and shapes. Previous work by other investigators amply documents these distinctions.[17,18,19,20,21,22]

To say that race and age explain variability in anthropometric dimensions tells only part of the story. If two or more racial groups are of different body sizes, but the bodies are proportioned the same way, then a sizing system

designed for one race will fit all; only the tariffs will be different. If, on the other hand, the bodies are proportioned differently, then sizing and designing will present problems.

Several variables from the Army 1966 survey have been examined to study the question of proportional differences between Blacks and Whites. (The numbers of subjects in the other racial groups in that survey are inadequate for this test.) To do this, relationships between variables have been considered using a regression model. For the specific Black/White comparison here, one dummy variable has been introduced into the model. The dummy variable technique is an application of analysis of covariance and is used to categorize the data into groups as needed.[23] The groups are Blacks and Whites.

The procedure used is as follows. The first null hypothesis tested is that the regression lines (one White, one Black) are the same. If that hypothesis is rejected, then the second step is to test the null hypothesis that the regression lines have equal slopes but different intercepts. Testing these hypotheses is nothing more than testing the equality of the regression coefficients.

Two pairs of variables are presented here for illustrative purposes. They can be seen as representative of classes of dimensions that will operate in a similar way.

The first variable pair is head circumference, the dependent variable, and face breadth, the independent variable. These were chosen because there are well known differences in head and face morphology of Blacks and Whites. The equations for these variables calculated from the 1966 Army data are:

head circ = 1.2247 (face breadth) + 389.785 (WHITES)
head circ = 1.4182 (face breadth) + 365.474 (BLACKS)

These are illustrated in Figure 9. For testing equality of lines, the F value associated with an alpha of 0.05 is 3.00. The F value comparing these two lines is 18.32, well above the 3.00 associated with 0.05. The null hypothesis that the lines are the same is rejected. The second step is to test whether the slopes are equal. For this test, the F associated with an alpha of 0.05 is 3.84. The F comparing these slopes is 5.18. The null hypothesis of equal slopes is also rejected. This shows a difference in allometric relationships of head and face variables between Blacks and Whites.

The second variable pair is crotch height, the dependent variable, and stature, the independent variable. This pair is representative of a class of dimensions that show different limb proportionality between Blacks and Whites. These equations are:

crotch height = 0.5815 (stature) - 178.447 (WHITES)
crotch height = 0.5733 (stature) - 143.759 (BLACKS)

First, the equality of the lines was tested (i.e., slopes are equal and intercepts are equal). The null hypothesis was rejected because the calculated F

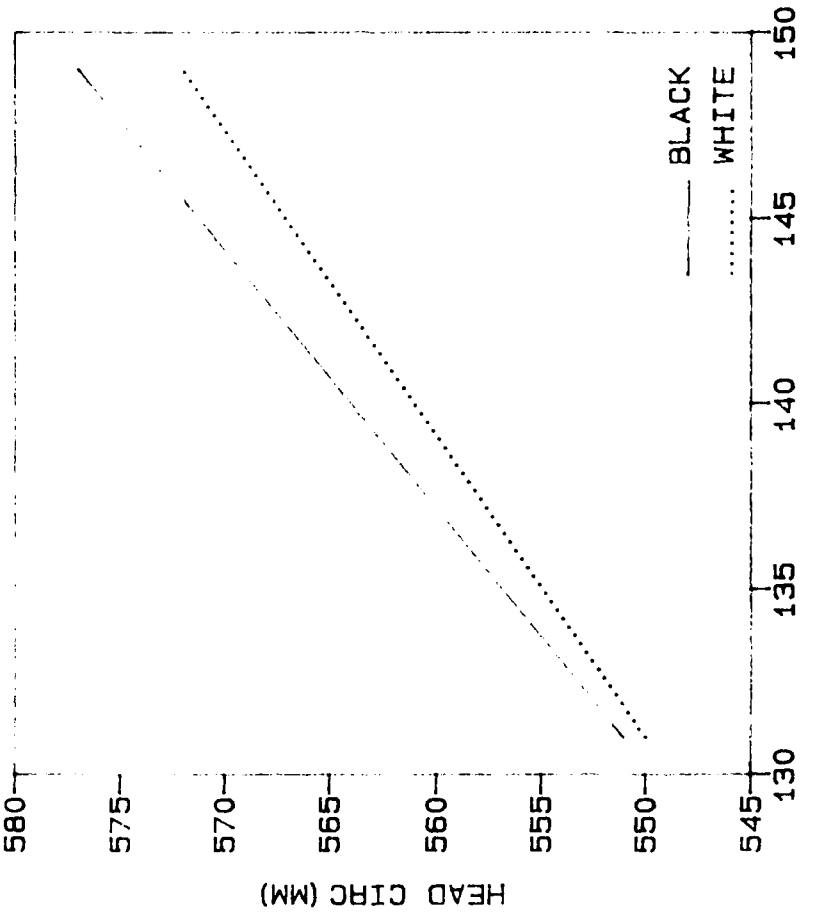

Figure 9. Face breadth vs. head circumference - Army 1966: Black and White males.

value is 25.52, which is greater than 3.00, the value associated with an alpha of 0.05. In the second step, testing equality of slopes, the F value for an alpha of 0.05 is 3.84. The calculated F for this comparison is 0.36. Therefore, the hypothesis of equal slopes cannot be rejected. This suggests that, while the relationship between stature and crotch height is the same for the two groups, for soldiers of a given stature their race will significantly affect their leg length. These regression lines are illustrated in Figure 10.

The conclusion that can be drawn from these illustrative analyses is that demographic variables, in this case race, can have a very significant effect on the relationships of anthropometric variables to each other. This, combined with the earlier analysis of variance, which tested mean values, suggests that these demographic variables can be a critical determinant of anthropometric dimensions. Thus, any change in demographic parameters can be expected to produce significant change in the anthropometric profile of the population.

If the case has been made that the current Army is demographically different from the existing anthropometric data base, and it has been further shown that demographic variables have an important influence on most anthropometric variables, then it follows that the applicability of anthropometric data in the current data base to the current active duty force must be viewed with grave doubts. This concern can be extended to the applicability of the data base to the Army of the 1990s and beyond.

Long-Term Comparisons

Long-term changes in body size, termed secular trend, have a particular bearing on the ability to generalize from the existing data base to the present Army population and to the Army of the 1990s. Although the analysis has demonstrated actual differences in some dimensions, and inferred differences in others, if these differences could be found to be attributable to a consistent secular trend, then it would be possible to predict the body size of soldiers of the future.

Many studies that present data on secular trend are conducted in conjunction with longitudinal growth studies. Because of this, it is necessary to separate two components of secular trend: the trend toward earlier physical maturation; and the trend toward larger adult body size. For example, in high altitude Peruvians there was no change in adult stature or weight in the period from 1945 to 1980.[24] Yet, age for age, during the growth years, there was a consistent increase of both stature and weight. Specifically, the stature increased from 0.6 cm to 2.7 cm/decade and weight increased from 0.3 kg to 2.4 kg/decade. Meredith[25] studied 9 and 11 year olds in 80 samples from all over the world, spread over 100 years, and found a steady increase through time. Yet, because adult statures and weights were not obtained, it is not clear from the data whether the trend is toward earlier maturation or toward larger body size. In another study, Meredith[26] presents longitudinal data to suggest that the secular trend in stature is roughly 1.3 cm/decade in late childhood, 1.9 cm/decade in adolescence, but only 0.6 cm/decade in adults.

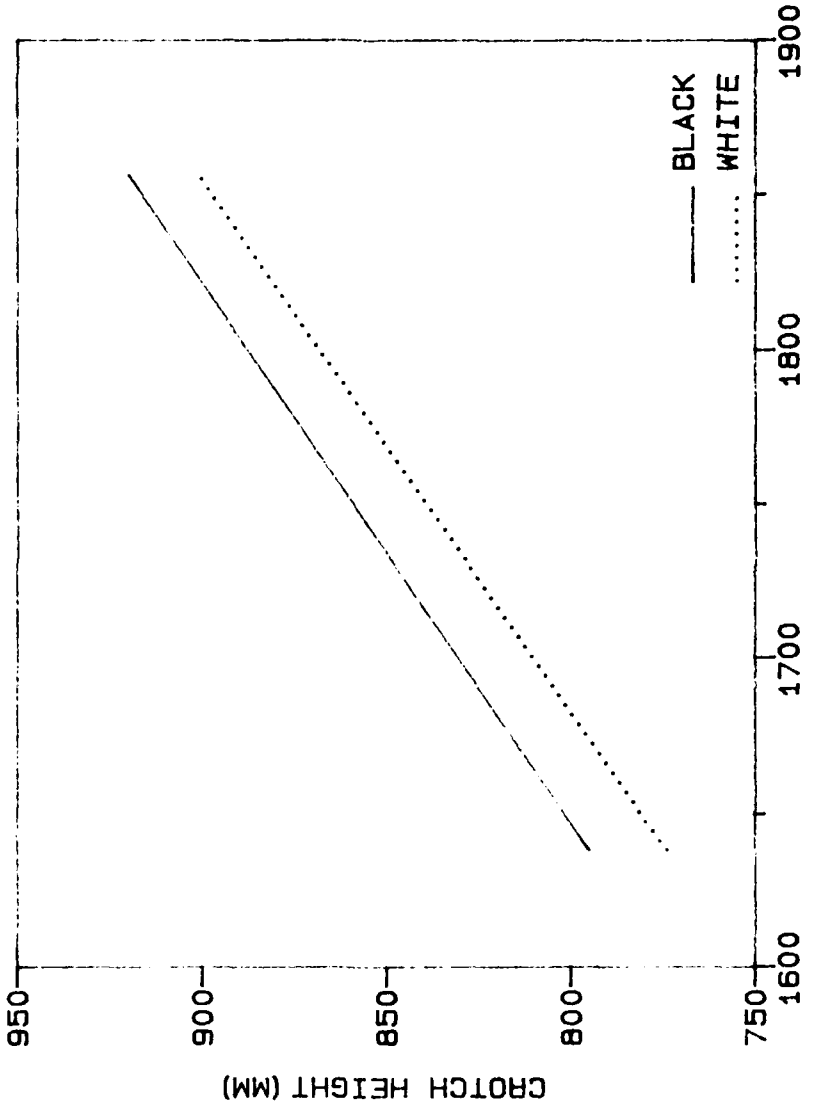

Figure 10. Stature vs. crotch height - Army 1966: Black and White males.

Military surveys, which are generally conducted on subjects either at or near the end of their growth periods, form an ideal data base for the study of secular trend in body size. Newman[27] compared samples of soldiers from World War II and the Korean War. The published paper does not provide tabular material on these comparisons, but by extrapolating from his data it can be seen that, age for age in individuals over age 23 (when growth in stature can be assumed to have stopped), there is an increase of approximately 1 cm for the time period between those two samples. The World War II sample was measured in 1946. The Korean data come from the medical records of war dead who died no later than 1950.

Annis[28] compiled stature data for a large number of U.S. military samples, dating from the Civil War. The U.S. data average an increase of approximately 1 cm/decade (Figure 11). This corresponds closely to figures for Europeans and Japanese (Figure 12)[28] and other groups world-wide.[29,30,31]

Examining these data for both U.S. military and civilians around the world, one might suppose that the secular trend toward increasing body size would continue indefinitely. If that assumption is to be made, one must first understand the causes of this gradual increase. Meredith[26] has thoroughly reviewed the literature and has compiled a long list of possible reasons for the observed secular trend. Among these are:

- decline in the frequency of illnesses which result in slowed growth;
- immigration resulting in heterosis and new population composition;
- increasing urbanization throughout the period of secular trend;
- increasing popularity of athletic pursuits;
- decrease in the prevalence of child labor;
- increase in overall community health and hygiene;
- assortative mating.

Improved diet may also play a part. If the items in the above list are responsible for at least part of the secular trend observed in the last century, then one might ask whether there are enough changes in those areas between the time of the most recent anthropometric surveys for the Army (1966/1977) and the present, and between the present and the mid-1990s to warrant a conclusion that the secular trend is continuing and will continue for the next decade. While some items on that list are still in effect (e.g., immigration, increasing urbanization, etc.), they are not occurring to the extent that they have in the past. Further, several other items on the list are no longer relevant, at least in the U.S. (e.g., child labor has not been permitted for some time; growth threatening illnesses are very rare). Based on these observations one might suspect that the secular trend is slowing down or ceasing in developed countries.

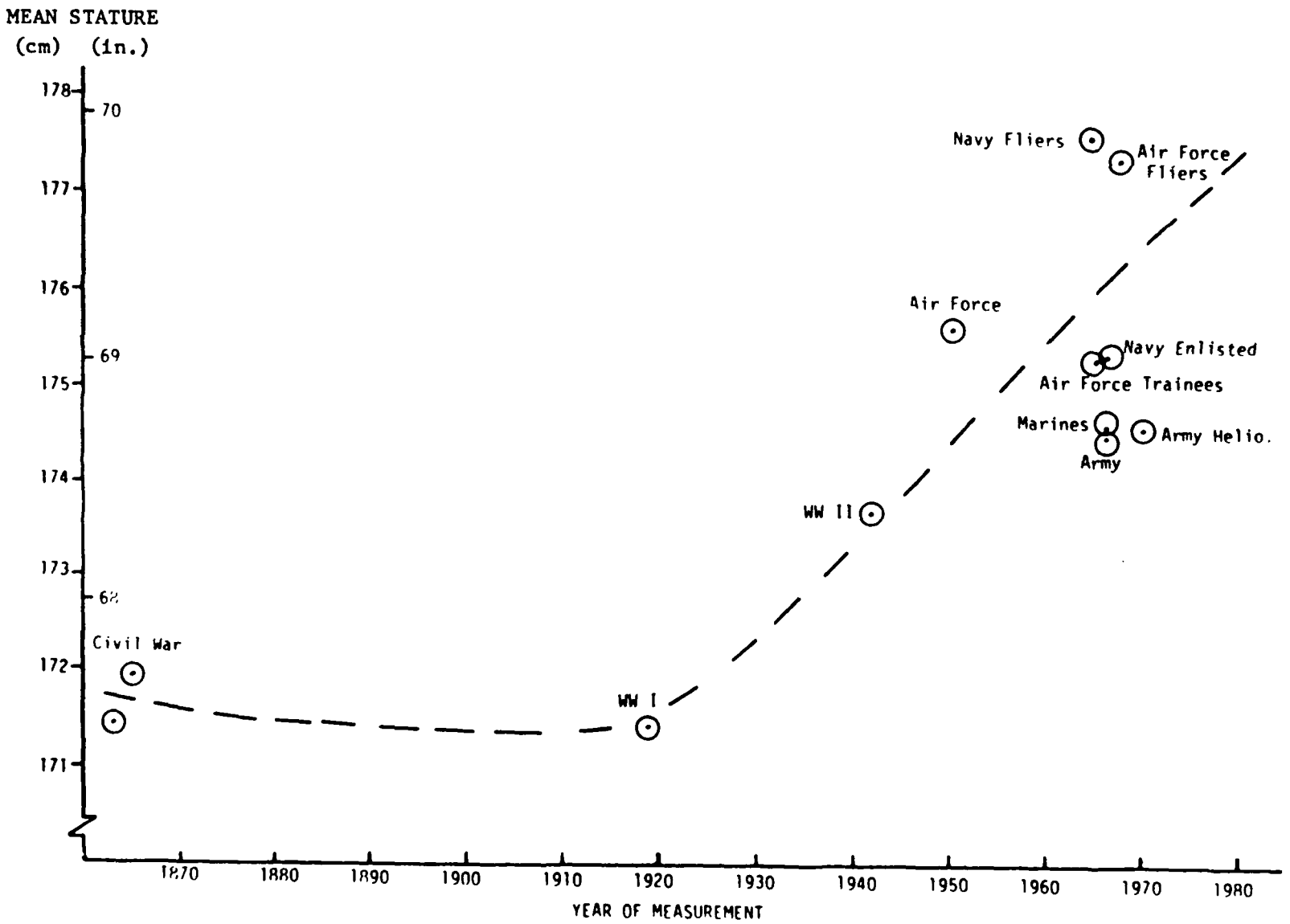

Figure 11. Secular trend in stature for young U.S. males: 1870-1980.

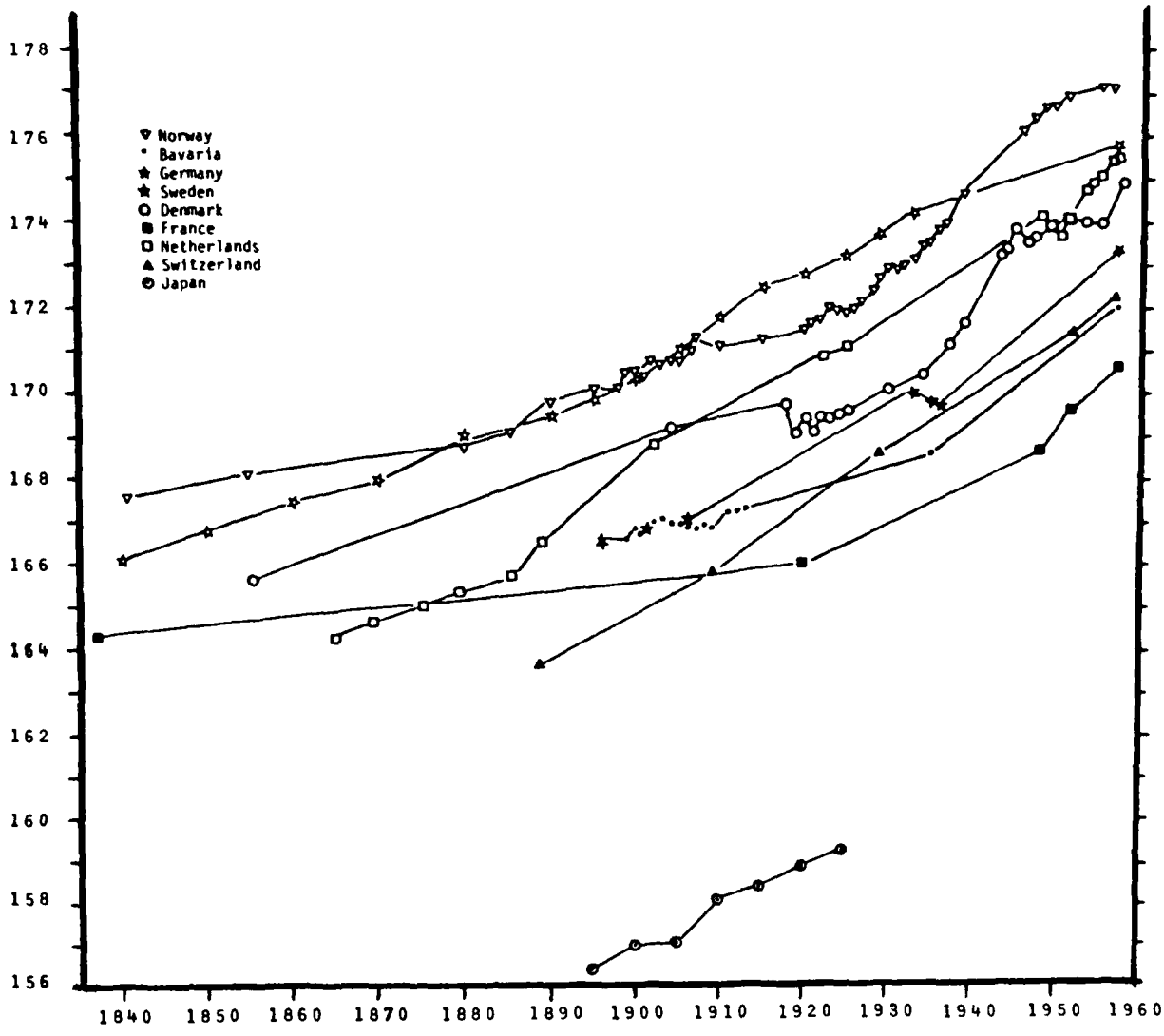

Figure 12. Secular increase in stature of young European and Japanese males: 1840-1960. After: Udjus[32] and Harbeck.[33]

There are data to show that in the U.S. the secular trend toward increased stature and weight is essentially at an end.[34] Compiling data on civilians from large surveys of all socioeconomic levels, investigators find no increase over the last several decades. Damon,[35] studying upper class males, felt that the trend had slowed to an imperceptible level by the 1960s. Maresh[36] found no change in body size in a 45 year period in the U.S. These authors cite the improving conditions in the several areas listed by Meredith[26] as the reasons for this observation. It should be pointed out that this may only be a plateau, after which the secular trend will continue, or a peak before a reversal of the secular trend.[34] When analyzing data of this sort, one cannot predict the future; one can only examine past events.

What are the implications of an active secular trend, or a slowing secular trend, or the lack of a secular trend in body size for the design needs of the U.S. Army? If the worst case model is assumed, i.e., secular trend continuing at maximum observed velocity, one would expect a 1 cm/decade increase from 1985 to the mid 1990s. If it is further assumed that the bodies are increasing proportionately, other body segment lengths would increase less than 1 cm in the next decade. Breadths and circumferences would also increase by small amounts. Differences as small as these are likely to be within the ranges of the body's changes from morning to evening, and to be well within measurement error. In the worst possible case, these increases in body size might cause an individual to move to a larger size in a clothing sizing system. Secular trend alone, even if it were demonstrated to be occurring in the 1980s, is not reason enough to discard any design now functioning for the the Army.

SUMMARY AND CONCLUSIONS

Significant demographic changes have already occurred in the Army and are likely to continue to occur in the foreseeable future. The effects of these changes on the anthropometric data base of the Army are much more profound than any that secular trend might cause.

The rapid demographic changes, specifically age, race and sex, in the Army have resulted in a population that is now very different, in body size as well as proportion, from that represented by the 1966/1977 anthropometric data base. The anthropometric dimensions likely to be most affected by these changes are precisely those most affected by race and age. There is not now an adequate data base to evaluate the proportional differences between persons of Hispanic origins and Blacks/Whites. The examinations that have been done comparing Blacks and Whites, however, show that a number of variable classes will likely be affected by significant changes in racial composition of the Army. Among these are head and face dimensions and those dimensions that have to do with limb length and body segment length. These, of course, are the most critical dimensions for the proper fit and function of clothing and personal protective equipment.

One could list specific items that might be affected more than others, but such a list would inevitably omit items that will be critical to the

Army's future. A more comprehensive approach to the problem would be to recognize the increasing heterogeneity of today's Army, and to collect a new set of anthropometric data that would more accurately represent the current population. If the samples are selected with sufficient care, such a survey could provide data that will be applicable to Army design problems for the present and for several decades to come.

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APPENDIX A.

Reclassification of National Extraction
From 1966 Army Into Race

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Reclassification of National Extraction
From 1966 Army Into Race
(Current U.S. Government Classification)

Racial Classification	Percent	Total Percent
BLACK - Non-Hispanic		**14.62**
Negro (American)	14.62	
WHITE - Non-Hispanic		77.61
White (American)	29.38	
Armenian	.04	
Austrian	.14	
Belgian	.08	
Canadian	.74	
Czechoslovakian	.68	
Danish	.42	
Dutch	1.65	
English	6.63	
Finnish	.15	
French	2.77	
German	12.05	
Greek	.06	
Hungarian	.53	
Irish	10.31	
Italian	4.12	
Lithuanian	.33	
Norwegian	1.28	
Polish	2.60	
Rumanian	.03	
Russian	.24	
Scotch	1.29	
Swedish	1.44	
Swiss	.06	
Turkish	.02	
Welsh	.29	
Yugoslavian	.12	
Other - European	.10	
Other - Near Eastern	.06	

APPENDIX A. (cont'd)

Racial Classification	Per-cent	Total Percent
HISPANIC		5.20
Cuban	.09	
Mexican	1.59	
Portugese	.47	
Puerto Rican	1.86	
Spanish	.89	
Other - S. American	.30	
AMERIND/ALASKAN NATIVE		1.49
Indian (American)	1.49	
ASIAN/PACIFIC ISLANDER		.87
Chinese	.08	
Filipino	.16	
Guamanian	.09	
Hawaiian	.09	
Japanese	.36	
Korean	.03	
Other - Asian	.06	
OTHER		.21
Other-Other	.21	

APPENDIX B.

Analysis of Variance Results

APPENDIX B.

Analysis of Variance Results

EFFECT: Race

DEPENDENT VARIABLE: Ankle Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	15061.84	3012.37	14.69***
Error	6648	1363580.68	205.11	
Total	6653	1378642.52		

DEPENDENT VARIABLE: Arm Scye Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	37910.15	7582.03	7.16***
Error	6648	7038556.85	1058.75	
Total	6653	7076467.00		

DEPENDENT VARIABLE: Ball of Foot Breadth

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	3818.71	763.74	26.00***
Error	6648	195247.91	29.37	
Total	6653	199066.62		

DEPENDENT VARIABLE: Ball of Foot Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	27719.33	5543.87	25.68***
Error	6648	1435209.54	215.89	
Total	6653	1462928.87		

* $p<.05$
** $p<.01$
*** $p<.001$

DEPENDENT VARIABLE: Ball of Foot Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	50165.32	10033.06	98.42***
Error	6648	677693.69	101.94	
Total	6653	727859.01		

DEPENDENT VARIABLE: Biceps Circumference, Flexed

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	146361.68	29272.34	39.86***
Error	6648	4882368.34	734.41	
Total	6653	5028730.02		

DEPENDENT VARIABLE: Biceps Circumference, Relaxed

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	49585.79	9917.16	13.39***
Error	6648	4925422.49	740.89	
Total	6653	4975008.28		

DEPENDENT VARIABLE: Bideltoid Diameter

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	25065.88	5013.18	7.83***
Error	6648	4254732.86	640.00	
Total	6653	4279798.74		

DEPENDENT VARIABLE: Bitragion Diameter

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	3886.89	777.38	24.81***
Error	6648	208304.90	31.33	
Total	6653	212191.79		

DEPENDENT VARIABLE: Bizygomatic Diameter

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	2376.79	475.36	15.29***
Error	6647	206603.73	31.08	
Total	6652	208980.52		

DEPENDENT VARIABLE: Buttock-Knee Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	509829.04	101965.81	138.02***
Error	6648	4911435.82	738.78	
Total	6653	5421264.86		

DEPENDENT VARIABLE: Buttock-Popliteal Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	367806.63	73561.33	128.53***
Error	6648	3804835.87	572.33	
Total	6653	4172642.50		

DEPENDENT VARIABLE: Calf Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	26268.51	5253.70	7.41***
Error	6648	4713085.42	708.95	
Total	6653	4739353.93		

DEPENDENT VARIABLE: Calf Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	339982.72	67996.54	100.14***
Error	6648	4513870.80	678.98	
Total	6653	4853853.52		

DEPENDENT VARIABLE: Cervicale Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	983968.43	196793.69	50.76***
Error	6648	25776300.54	3877.30	
Total	6653	26760268.97		

DEPENDENT VARIABLE: Chest Breadth, Skin

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	20666.64	4133.33	9.03***
Error	6648	3042329.60	457.63	
Total	6653	3062996.24		

DEPENDENT VARIABLE: Chest Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	180325.84	36065.17	8.11***
Error	6648	29556909.77	4445.99	
Total	6653	29737235.61		

DEPENDENT VARIABLE: Chest Depth

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	12051.24	2410.25	6.08***
Error	6648	2634117.39	396.23	
Total	6653	2646168.63		

DEPENDENT VARIABLE: Crotch Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	707580.49	141516.09	67.99***
Error	6648	13837704.08	2081.48	
Total	6653	14545284.57		

DEPENDENT VARIABLE: Eye Height, Sitting

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	1106004.38	221200.86	199.17***
Error	6648	7383285.80	1110.60	
Total	6653	8489290.18		

DEPENDENT VARIABLE: Face Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	4073.82	814.77	18.89***
Error	6647	286735.80	43.14	
Total	6652	290809.62		

DEPENDENT VARIABLE: Foot Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	79253.03	15850.61	100.62***
Error	6648	1047298.50	157.54	
Total	6653	1126551.53		

DEPENDENT VARIABLE: Forearm Circumference, Flexed

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	119482.59	23896.52	53.74***
Error	6648	2956411.37	444.71	
Total	6653	3075893.96		

DEPENDENT VARIABLE: Forearm-Hand Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	454445.98	90889.20	195.45***
Error	6648	3091508.89	465.03	
Total	6653	3545954.87		

DEPENDENT VARIABLE: Functional Reach

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	891536.29	178307.26	80.61***
Error	6646	14700719.66	2211.97	
Total	6651	15592255.95		

DEPENDENT VARIABLE: Hand Breadth

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	2990.29	598.06	25.32***
Error	6647	156985.71	23.62	
Total	6652	159976.00		

DEPENDENT VARIABLE: Hand Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	24757.34	4951.47	39.41***
Error	6648	835282.36	125.64	
Total	6653	860039.70		

DEPENDENT VARIABLE: Hand Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	71331.62	14266.32	173.82***
Error	6648	545644.63	82.08	
Total	6653	616976.25		

DEPENDENT VARIABLE: Head Breadth

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	2728.70	545.74	16.12***
Error	6648	225095.21	33.86	
Total	6653	227823.91		

DEPENDENT VARIABLE: Head Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	18265.31	3653.06	14.28***
Error	6648	1700775.46	255.83	
Total	6653	1719040.77		

DEPENDENT VARIABLE: Head Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	4442.30	888.46	14.29***
Error	6648	413450.69	62.19	
Total	6653	417892.99		

DEPENDENT VARIABLE: Head Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	14189.79	2837.96	54.99***
Error	6648	343105.49	51.61	
Total	6653	357295.28		

DEPENDENT VARIABLE: Heel-Ankle Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	102602.28	20520.46	78.78***
Error	6648	1731674.95	260.48	
Total	6653	1834277.23		

DEPENDENT VARIABLE: Heel Breadth

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	19131.23	3826.25	199.43***
Error	6648	127548.24	19.19	
Total	6653	146679.47		

DEPENDENT VARIABLE: Hip Breadth

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	58938.82	11787.76	29.89***
Error	6648	2622101.68	394.42	
Total	6653	2681040.50		

DEPENDENT VARIABLE: Hip Breadth, Sitting

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	97704.85	19540.97	35.41***
Error	6648	3669009.20	551.90	
Total	6653	3766714.05		

DEPENDENT VARIABLE: Hip Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	171789.45	34357.89	8.85***
Error	6648	25804214.62	3881.50	
Total	6653	25976004.07		

DEPENDENT VARIABLE: Instep Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	65186.72	13037.34	49.75***
Error	6648	1742280.49	262.08	
Total	6653	1807467.21		

DEPENDENT VARIABLE: Interpupillary Distance

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	10899.97	2179.99	152.34***
Error	6646	95127.74	14.31	
Total	6651	106027.71		

DEPENDENT VARIABLE: Interscye Distance

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	15646.25	3129.25	3.16**
Error	6648	6591771.72	991.54	
Total	6653	6607417.97		

DEPENDENT VARIABLE: Interscye Maximum

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	43438.76	8687.75	6.37***
Error	6648	9063471.35	1363.34	
Total	6653	9106910.11		

DEPENDENT VARIABLE: Knee Height, Sitting

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	266471.89	53294.38	75.39***
Error	6648	4699521.30	706.91	
Total	6653	4965993.19		

DEPENDENT VARIABLE: Lower Thigh Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	34357.15	6871.43	4.61***
Error	6648	9905407.53	1489.98	
Total	6653	9939764.68		

DEPENDENT VARIABLE: Maximum Forearm-Forearm Breadth

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	24022.97	4804.59	2.70*
Error	6648	11810731.45	1776.58	
Total	6653	11834754.42		

DEPENDENT VARIABLE: Mid-Shoulder Height, Sitting

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	782083.73	156416.75	175.09***
Error	6648	5938937.95	893.34	
Total	6653	6721021.68		

DEPENDENT VARIABLE: Neck Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	33170.53	6634.11	15.68***
Error	6647	2811819.64	423.02	
Total	6652	2844990.17		

DEPENDENT VARIABLE: Occiput-External Canthus

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	36625.52	7325.10	81.25***
Error	6648	599329.12	90.15	
Total	6653	635954.64		

DEPENDENT VARIABLE: Occiput-Nasal Root

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	14366.55	2873.31	57.61***
Error	6648	331584.82	49.88	
Total	6653	345951.37		

DEPENDENT VARIABLE: Occiput-Pronasale

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	21924.15	4384.83	66.35***
Error	6648	439320.15	66.08	
Total	6653	461244.30		

DEPENDENT VARIABLE: Occiput-Tragion

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	17359.97	3471.99	24.96***
Error	6648	924893.26	139.12	
Total	6653	942253.23		

DEPENDENT VARIABLE: Palm Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	24909.59	4981.92	139.32***
Error	6648	237727.77	35.76	
Total	6653	262637.36		

DEPENDENT VARIABLE: Patella Top Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	304246.61	60849.32	60.18***
Error	6648	6721997.54	1011.13	
Total	6653	7026244.15		

DEPENDENT VARIABLE: Popliteal Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	115394.05	23078.81	38.01***
Error	6648	4036659.54	607.20	
Total	6653	4152053.59		

DEPENDENT VARIABLE: Shoulder Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	138586.84	27717.37	6.83***
Error	6648	26988270.29	4059.61	
Total	6653	27126857.13		

DEPENDENT VARIABLE: Shoulder-Elbow Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	80510.99	16102.20	47.99***
Error	6648	2230732.99	335.55	
Total	6653	2311243.98		

DEPENDENT VARIABLE: Shoulder Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	878346.51	175669.30	46.84***
Error	6648	24930244.80	3750.04	
Total	6653	25808591.31		

DEPENDENT VARIABLE: Shoulder Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	63163.96	12632.79	32.90***
Error	6648	2552373.16	383.93	
Total	6653	2615537.12		

DEPENDENT VARIABLE: Sitting Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	1354383.40	270876.68	237.28***
Error	6648	7589165.54	1141.57	
Total	6653	8943548.94		

DEPENDENT VARIABLE: Sleeve Inseam

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	318895.98	63779.20	95.35***
Error	6648	4446998.59	668.92	
Total	6653	4765894.57		

DEPENDENT VARIABLE: Sleeve Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	521228.08	104245.62	70.07***
Error	6648	9890895.54	1487.80	
Total	6653	10412123.62		

DEPENDENT VARIABLE: Stature

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	1120212.15	224042.43	53.25***
Error	6648	27970403.76	4207.34	
Total	6653	29090615.91		

DEPENDENT VARIABLE: Thumb Crotch-Forefinger Base

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	3629.83	725.97	27.45***
Error	6648	175840.71	26.45	
Total	6653	179470.54		

DEPENDENT VARIABLE: Upper Thigh Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	73686.46	14737.29	6.43***
Error	6648	15247894.15	2293.61	
Total	6653	15321580.61		

DEPENDENT VARIABLE: Vertical Reach, Sitting

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	591670.67	118334.13	36.02***
Error	6648	21838340.40	3284.95	
Total	6653	22430011.07		

DEPENDENT VARIABLE: Vertical Trunk Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	932801.81	186560.36	26.35***
Error	6648	47073064.89	7080.79	
Total	6653	48005866.70		

DEPENDENT VARIABLE: Waist Back Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	222060.85	44412.17	38.64***
Error	6648	7640960.42	1149.36	
Total	6653	7863021.27		

DEPENDENT VARIABLE: Waist Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	634502.56	126900.51	19.25***
Error	6647	43813202.77	6591.43	
Total	6652	44447705.33		

DEPENDENT VARIABLE: Waist Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	820732.99	164146.60	59.49***
Error	6648	18341824.66	2759.00	
Total	6653	19162557.65		

DEPENDENT VARIABLE: Weight

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	32210.94	6442.19	11.91***
Error	6643	3594505.03	541.10	
Total	6648	3626715.97		

DEPENDENT VARIABLE: Wrist Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Race	5	9444.62	1888.92	25.10***
Error	6648	500353.62	75.26	
Total	6653	1509798.24		

EFFECT: Age Groups

DEPENDENT VARIABLE: Ankle Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	2444.32	407.39	1.97
Error	6675	1380728.04	206.85	
Total	6681	1383172.36		

DEPENDENT VARIABLE: Arm Scye Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	415996.64	69332.77	69.16***
Error	6675	6691609.16	1002.49	
Total	6681	7107605.80		

DEPENDENT VARIABLE: Ball of Foot Breadth

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	481.42	80.24	2.69*
Error	6675	199202.25	29.84	
Total	6681	199683.67		

DEPENDENT VARIABLE: Ball of Foot Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	957.68	159.61	0.73
Error	6675	1466779.77	219.74	
Total	6681	1467737.45		

DEPENDENT VARIABLE: Ball of Foot Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	1664.97	277.50	2.54*
Error	6675	728235.33	109.10	
Total	6681	729900.30		

DEPENDENT VARIABLE: Biceps Circumference, Flexed

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	234778.56	39129.76	54.22***
Error	6675	4817603.58	721.74	
Total	6681	5052382.14		

DEPENDENT VARIABLE: Biceps Circumference, Relaxed

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	263641.24	43940.21	61.91***
Error	6675	4737199.53	709.69	
Total	6681	5000840.77		

DEPENDENT VARIABLE: Bideltoid Diameter

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	197671.13	32945.19	53.63***
Error	6675	4100453.75	614.30	
Total	6681	4298124.88		

DEPENDENT VARIABLE: Bitragion Diameter

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	6915.60	1152.60	37.32***
Error	6675	206155.58	30.88	
Total	6681	213071.18		

DEPENDENT VARIABLE: Bizygomatic Diameter

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	7949.23	1324.87	43.84***
Error	6674	201705.95	30.22	
Total	6680	209655.18		

DEPENDENT VARIABLE: Buttock-Knee Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	26338.39	4389.73	5.42***
Error	6675	5410433.03	810.55	
Total	6681	5436771.42		

DEPENDENT VARIABLE: Buttock-Popliteal Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	16647.44	2774.57	4.44***
Error	6675	4167939.26	624.41	
Total	6681	4184586.70		

DEPENDENT VARIABLE: Calf Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	34841.94	5806.99	8.21***
Error	6675	4719285.14	707.01	
Total	6681	4754127.08		

DEPENDENT VARIABLE: Calf Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	5999.66	999.94	1.37
Error	6675	4864995.02	728.84	
Total	6681	4870994.68		

DEPENDENT VARIABLE: Cervicale Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	64222.04	10703.67	2.67*
Error	6675	26794464.84	4014.15	
Total	6681	26858686.88		

DEPENDENT VARIABLE: Chest Breadth, Skin

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	128764.74	21460.79	48.63***
Error	6675	2945959.59	441.34	
Total	6681	3074724.33		

DEPENDENT VARIABLE: Chest Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	2251865.01	375310.83	90.68***
Error	6675	27628153.94	4139.05	
Total	6681	29880018.95		

DEPENDENT VARIABLE: Chest Depth

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	298739.82	49789.97	140.83***
Error	6675	2359957.49	353.55	
Total	6681	2658697.31		

DEPENDENT VARIABLE: Crotch Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	187261.82	31210.30	14.46***
Error	6675	14411160.89	2158.98	
Total	6681	14598422.71		

DEPENDENT VARIABLE: Eye Height, Sitting

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	46427.38	7737.90	6.10***
Error	6675	8466687.41	1268.42	
Total	6681	8513114.79		

DEPENDENT VARIABLE: Face Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	915.41	152.57	3.50**
Error	6674	291321.14	43.65	
Total	6680	292236.55		

DEPENDENT VARIABLE: Foot Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	1724.15	287.36	1.70
Error	6675	1128664.29	169.09	
Total	6681	1130388.44		

DEPENDENT VARIABLE: Forearm Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	99223.55	16537.26	36.88***
Error	6675	2992765.77	448.35	
Total	6681	3091989.32		

DEPENDENT VARIABLE: Forearm-Hand Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	11221.86	1870.31	3.52**
Error	6675	3551537.34	532.07	
Total	6681	3562759.20		

DEPENDENT VARIABLE: Functional Reach

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	12682.96	2113.83	0.90
Error	6673	15679177.65	2349.65	
Total	6679	15691860.61		

DEPENDENT VARIABLE: Hand Breadth

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	328.26	54.71	2.27*
Error	6674	160695.71	24.08	
Total	6680	161023.97		

DEPENDENT VARIABLE: Hand Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	6350.70	1058.45	8.23***
Error	6675	858163.44	128.56	
Total	6681	864514.14		

DEPENDENT VARIABLE: Hand Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	1925.94	320.99	3.47**
Error	6675	617751.34	92.55	
Total	6681	619677.28		

DEPENDENT VARIABLE: Head Breadth

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	3158.79	526.47	15.58***
Error	6675	225625.61	33.80	
Total	6681	228784.40		

DEPENDENT VARIABLE: Head Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	48471.01	8078.50	32.14***
Error	6675	1678032.73	251.39	
Total	6681	1726503.74		

DEPENDENT VARIABLE: Head Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	2391.77	398.63	6.38***
Error	6675	417119.18	62.49	
Total	6681	419510.95		

DEPENDENT VARIABLE: Head Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	5980.14	996.69	18.84***
Error	6675	353151.97	52.91	
Total	6681	359132.11		

DEPENDENT VARIABLE: Heel-Ankle Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	7023.56	1170.59	4.26***
Error	6675	1832317.99	274.50	
Total	6681	1839341.55		

DEPENDENT VARIABLE: Heel Breadth

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	3072.93	512.16	23.73***
Error	6675	144070.28	21.58	
Total	6681	147143.21		

DEPENDENT VARIABLE: Hip Breadth

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	89617.36	14936.23	38.27***
Error	6675	2605147.09	390.28	
Total	6681	2694764.45		

DEPENDENT VARIABLE: Hip Breadth, Sitting

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	147786.35	24631.06	45.17***
Error	6675	3639602.78	545.26	
Total	6681	3787389.13		

DEPENDENT VARIABLE: Hip Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	1223804.30	203967.38	54.76***
Error	6675	24862989.69	3724.79	
Total	6681	26086793.99		

DEPENDENT VARIABLE: Instep Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	2115.59	352.59	1.30
Error	6675	1813343.71	271.66	
Total	6681	1815459.30		

DEPENDENT VARIABLE: Interpupillary Distance

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	2175.14	362.52	23.22***
Error	6673	104170.45	15.61	
Total	6679	106345.59		

DEPENDENT VARIABLE: Interscye Distance

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	62560.98	10426.83	10.56***
Error	6675	6591212.95	987.45	
Total	6681	6653773.93		

DEPENDENT VARIABLE: Interscye Maximum

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	121968.99	20328.17	15.02***
Error	6675	9035130.91	1353.58	
Total	6681	9157099.90		

DEPENDENT VARIABLE: Knee Height, Sitting

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	5193.65	865.61	1.16
Error	6675	4985054.26	746.82	
Total	6681	4990247.91		

DEPENDENT VARIABLE: Lower Thigh Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	99026.04	16504.34	11.14***
Error	6675	9886744.20	1481.16	
Total	6681	9985770.24		

DEPENDENT VARIABLE: Maximum Forearm-Forearm Breadth

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	722750.84	120458.47	72.05***
Error	6675	11159717.20	1671.87	
Total	6681	11882468.04		

DEPENDENT VARIABLE: Mid-Shoulder Height, Sitting

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	7014.01	1169.00	1.16
Error	6675	6737721.97	1009.40	
Total	6681	6744735.98		

DEPENDENT VARIABLE: Neck Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	169252.94	28208.82	70.06***
Error	6674	2687290.15	402.65	
Total	6680	2856543.09		

DEPENDENT VARIABLE: Occiput-External Canthus

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	12631.26	2105.21	22.46***
Error	6675	625681.05	93.73	
Total	6681	638312.31		

DEPENDENT VARIABLE: Occiput-Nasal Root

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	4964.78	827.46	16.13***
Error	6675	342475.53	51.31	
Total	6681	347440.31		

DEPENDENT VARIABLE: Occiput-Pronasale

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	7767.94	1294.66	18.96***
Error	6675	455755.60	68.28	
Total	6681	463523.54		

DEPENDENT VARIABLE: Occiput-Tragion

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	1678.11	279.68	1.98
Error	6675	944609.14	141.51	
Total	6681	946287.25		

DEPENDENT VARIABLE: Palm Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	383.23	63.87	1.62
Error	6675	263682.82	39.50	
Total	6681	264066.05		

DEPENDENT VARIABLE: Patella Top Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	4938.32	823.05	0.78
Error	6675	7039349.31	1054.58	
Total	6681	7044287.63		

DEPENDENT VARIABLE: Popliteal Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	55064.09	9177.35	14.90***
Error	6675	4111760.33	615.99	
Total	6681	4166824.42		

DEPENDENT VARIABLE: Shoulder Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	1245084.39	207514.07	53.26***
Error	6675	26006136.47	3896.05	
Total	6681	27251220.86		

DEPENDENT VARIABLE: Shoulder-Elbow Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	13298.94	2216.49	6.41***
Error	6675	2307124.14	345.64	
Total	6681	2320423.08		

DEPENDENT VARIABLE: Shoulder Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	69854.27	11642.38	3.01**
Error	6675	25817753.03	3867.83	
Total	6681	25887607.30		

DEPENDENT VARIABLE: Shoulder Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	11148.67	1858.11	4.73***
Error	6675	2620724.22	392.62	
Total	6681	2631872.89		

DEPENDENT VARIABLE: Sitting Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	52072.31	8678.72	6.50***
Error	6675	8918649.15	1336.13	
Total	6681	8970721.46		

DEPENDENT VARIABLE: Sleeve Inseam

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	11007.96	1834.66	2.56*
Error	6675	4779116.59	715.97	
Total	6681	4790124.55		

DEPENDENT VARIABLE: Sleeve Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	70961.95	11826.99	7.60***
Error	6675	10387235.34	1556.14	
Total	6681	10458197.29		

DEPENDENT VARIABLE: Stature

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	112624.48	18770.75	4.31***
Error	6675	29077594.47	4356.19	
Total	6681	29190218.95		

DEPENDENT VARIABLE: Thumb Crotch-Forefinger Base

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	44.50	7.42	0.28
Error	6675	179895.61	26.95	
Total	6681	179940.11		

DEPENDENT VARIABLE: Upper Thigh Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	371629.65	61938.27	27.53***
Error	6675	15019197.59	2250.07	
Total	6681	15390827.24		

DEPENDENT VARIABLE: Vertical Reach, Sitting

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	56363.74	9393.96	2.79*
Error	6675	22450804.44	3363.42	
Total	6681	22507168.18		

DEPENDENT VARIABLE: Vertical Trunk Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	956208.85	159368.14	22.53***
Error	6675	47223289.99	7074. 65	
Total	6681	48179498.84		

DEPENDENT VARIABLE: Waist Back Length

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	91916.03	15319.34	13.09***
Error	6675	7812387.34	1170.40	
Total	6681	7904303.37		

DEPENDENT VARIABLE: Waist Circumfernce

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	4094190.98	682365.16	112.19***
Error	6674	40592260.26	6082.15	
Total	6680	44686451.24		

DEPENDENT VARIABLE: Waist Height

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	31433.07	5238.85	1.82
Error	6675	19227019.78	2880.45	
Total	6681	19258452.85		

DEPENDENT VARIABLE: Weight

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	155751.69	25958.62	49.67***
Error	6670	3485895.00	522.62	
Total	6676	3641646.69		

DEPENDENT VARIABLE: Wrist Circumference

Sources of Variation	df	Sums of Squares	Mean Square	F
Age Group	6	6724.25	1120.71	14.80***
Error	6675	505556.31	75.74	
Total	6681	512280.56		